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R10-TP-67
April, 1997

State of Alaska,
Department of
Natural
Resources,
Division of
Forestry

Forest Health Management Report

Forest Insect and Disease Conditions in Alaska--1996

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ERRATA: Page 10, the acreage noted for US Forest Service Lands in Chart 2 should read Tongass - 48% (12,730 acres) and Chugach - 52% (14,042 acres). The total acres are correct.

FOREST INSECT AND DISEASE CONDITIONS IN ALASKA -- 1996

General Technical Report R10-TP-67

April, 1997

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FOREST INSECT AND DISEASE CONDITIONS IN ALASKA -- 1996

CONDITIONS IN BRIEF

Insect activity showed a marked increase in 1996. The most ecologically important disturbance agent was the **spruce bark beetle**; infestations were detected on over 1.13 million acres. In south-central Alaska, the infestation on the lower Kenai Peninsula below Tustamena Lake seems to be slowing, mainly due to lack of suitable host material. Meanwhile, the beetle continues to make inroads into the central part of the Kenai Peninsula around Skilak Lake, the southwestern part of Kachemak Bay near Seldovia, the Valleys of Turnagain Arm, and the west side of Cook Inlet. In the Anchorage Bowl, infestations are moving down from the Hillside area and spreading across the city. Beetle pressure also seems to be building in the Mat-Su valley. **Engraver beetle** (*Ips* sp.) Activity in interior Alaska increased from 5,621 acres in 1995 to 7,659 acres, primarily along the Yukon River from Circle to Tanana and the Tanana River from Fairbanks to Nenana.

Among the defoliators, **Larch Sawfly** and **willow defoliation** also had large increases, from 117,000 and 6,000 acres in 1995 to 607,000 and 50,000 acres in 1996, respectively. Larch sawfly defoliated almost every larch from Fairbanks to McGrath. While a ground check noted a re-flushing of new growth late in the season, concern still exists for larch beetle-caused mortality developing in these weakened stands. Willow defoliation took a major leap in interior Alaska especially along the Yukon and Porcupine Rivers. Of greater concern is the apparent willow mortality noted along the Yukon from its confluence with the Porcupine River downstream. Willow mortality could adversely impact moose populations. Conversely, the largest decrease in insect damage occurred with the **large aspen tortrix**, down nearly 26,000 acres to 6,447 in 1996. Tortrix populations were scattered across south-central and interior Alaska in isolated patches.

In southeast Alaska, **spruce beetle** activity continued to increase. The acreage where spruce beetle occurred doubled from 16,500 acres in 1995 to 35,700 acres in 1996. Twenty seven percent (9,500 acres) occurred on islands bordering the Pacific Ocean. This infestation might have been identified as early as 1994-5 but the western edge of the islands were not aerially surveyed. The beetle infestation in Haines increased to 13,800 acres of new and on-going activity. The 1994 spruce beetle outbreak on the north side of the Taku River has expanded to 4,850 acres. The beetle outbreak in lower Glacier Bay continues to increase on the ridge east of Gustavus from 2,200 acres in 1995 to 4,000 acres in 1996. The infestation at the mouth of the Stikine River area did not increase in area from the 1995 aerial detection. Scattered damage from ***Ips*** **engravers** occurred throughout southeast Alaska.

Trees defoliated by **black-headed budworm** were recorded on only 550 acres in southeast Alaska and 700 acres in south-central Alaska compared to nearly 13,000 acres in 1995 and 194,000 acres in 1994. **Hemlock sawfly** defoliation levels increased from 1,100 acres in 1995 to 8,250 acres in 1996. Approximately half of the acres defoliated were southwest of Mole Harbor, Admiralty Island and on the southeast end of Mitkof Island. **Spruce needle aphid** defoliation occurred throughout southeast Alaska.

The most important diseases of Alaskan forests during 1996 were **wood decay** of live trees, **hemlock dwarf mistletoe**, and **Yellow-cedar decline**. All three are chronic factors that significantly influence ecological conditions including forest structure, composition, and succession. In addition, each caused commercial loss to the timber resource. Heart rot and butt rot fungi caused large amounts of cull in all tree species in Alaska, particularly in coastal forests where approximately 1/3 of the gross volume of forests is defective. Decay in living hardwoods throughout the state was considerable. Wildlife habitat is produced directly by heart rot and dwarf mistletoe through the formation of tree cavities and witches brooms. Hemlock dwarf mistletoe continued to cause growth loss, top-kill, and mortality in old-growth forests of southeast Alaska; its impact in managed stands depends on the abundance of large infected trees left after harvesting. Approximately 475,000 acres of yellow-cedar decline have been mapped throughout an extensive area of southeast Alaska. Snags of yellow-cedar accumulate on affected sites and forest composition is substantially altered as yellow-cedar trees die giving way to other tree species. Salvage opportunities for this valuable resource are now being recognized.

Foliar diseases of conifers had negligible ecological significance and were generally at moderate levels throughout Alaska in 1996, except for an outbreak of the **hemlock needle rust** near Yakutat. Hemlock canker continued at low levels in 1996 after causing mortality along roads on several islands in southeast Alaska during the early 1990's. Canker and foliar fungi caused a large, but unmeasured damage to hardwood species in interior Alaska.

Porcupines continued to damage Sitka spruce and western hemlock in young-growth stands. **Brown bears** caused a high incidence of wounding on the lower boles of yellow-cedar in southeast Alaska.

Table 1 on the next page summarizes Alaska forest insect and disease activity by ownership and causal agent.

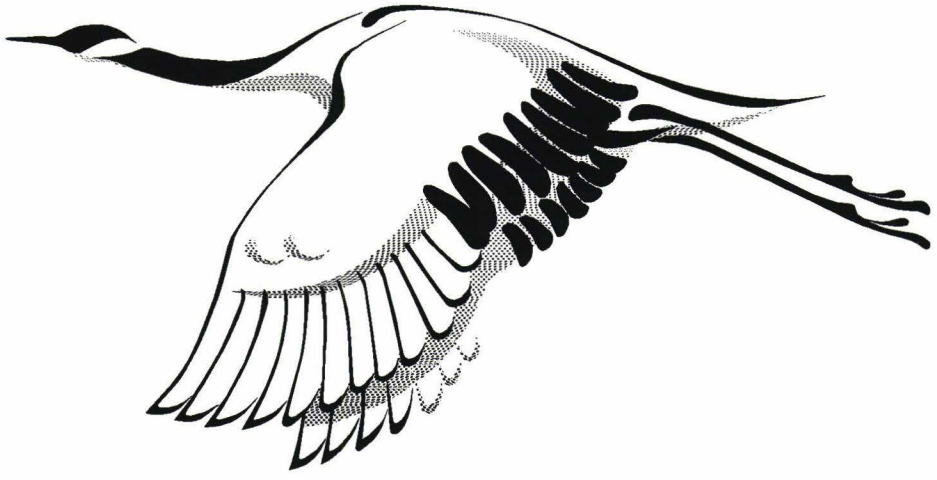


Table 1. 1996 Forest insect and disease activity (acres) in Alaska by land ownership and agent[1]

Damage Agent	*State & Private*	*National Forest*	*Other Federal*	*Native Corp.*	*1996 Total*	*1995 Total*
Spruce beetle	418,357	26,772	346,873	338,754	1,130,756	892,831
Spruce beetle/Engravers	72	--	1,917	4,293	6,282	--
Engravers	1,683	341	3,855	1,780	7,659	5,621
Spruce budworm/coneworm	53,035	--	86,688	96,213	235,936	279,168
Black-headed budworm	123	1,032	72	--	1,227	12,995
Hemlock sawfly	1,570	3,152	3,254	275	8,251	1,103
Spruce needle aphid	139	171	159	5	474	68
Large aspen tortrix	4,602	--	1,213	632	6,447	32,347
Conifer defoliation	89	1,269	--	49	1,407	5,467
Aspen defoliation[2]	--	--	--	--	--	437
Birch defoliation	1,838	--	363	977	3,178	896
Cottonwood defoliation	2,161	413	1,919	2,025	6,518	3,505
Willow defoliation	1,204	10	15,662	33,236	50,112	5,573
Larch sawfly	354,319	--	194,544	58,064	606,927	116,882
Spruce bud moth	--	--	390	--	390	1,243
Spruce broom rust	23	40	33	102	198	--
Spruce needle rust	1,517	--	1,899	8	3,424	2,855
Yellow-cedar decline[3]	6,603	452,333	----	15,928	474,864	595,000
Water damage	3,397	882	983	373	5,635	4,775
Blowdown/windthrow	47	416	23	132	618	49
Landslide damage	12	357	74	55	498	465
Porcupine damage	46	518	--	69	633	375
Total acres by ownership	**850,837**	**487,706**	**659,921**	**552,970**	**2,551,434**	**1,961,655**

[1] Table entries do not include many of the most destructive diseases (e.g., wood decays and dwarf mistletoe) because these losses are not detectable in aerial surveys.

[2] No aspen defoliation other than by large aspen tortrix was noted for 1996.

[3] Value of yellow-cedar decline is not restricted to the acreage with a high concentration of dying trees for this year; it represents stands that generally have long-dead trees, recently-dead trees, dying trees, and some healthy trees. See discussion of yellow-cedar decline for a detailed listing of acreage affected by island and Ranger District. Note: The difference in acres from 1995 to 1996 is because of better refinement in mapping and GIS abilities.

STATUS OF INSECTS

ROLE OF DISTURBANCE IN ECOSYSTEM MANAGEMENT

A key premise of ecosystem management (based on natural variability) is that native species have adapted to, and in part, evolved with natural disturbance events. Species loss and ecosystem change have been observed in areas where "natural" disturbance regimes have been substantially altered. Disturbances, large and small, are responsible for the way current landscapes appear and function today. Disturbances of various kinds and intensities will determine the structure, composition, and function of future landscapes. Alaska ecosystems are shaped/produced by disturbances. Just note the effects of glaciation, earthquakes, tidal waves, fire, wind, flooding, etc. Disturbance events such as fire, insect, and disease outbreaks create and maintain a shifting mosaic of landscape patterns. Both fire and flooding are responsible for spruce and birch regeneration in south-central and interior Alaska; windthrow is important in southeast Alaska. Fire burns across the landscape in an irregular and uneven manner. The burned surface may or may not be essentially the same as the pre-burned surface. Succession after fire in Alaskan forest ecosystems is complex and related to site, fire, climate, type and age of the vegetation present before fire, and plant species available for sprouting or invasion after fire. Alaska insect communities, probably one of the largest components of forest ecosystems, are also "creatures" of disturbance as well as agents of disturbance. Arctic/ boreal insects are characterized by having few species and large population numbers. These insects are opportunistic in their behaviors. They respond quickly to disturbances in climate, food, and breeding material. The spruce bark beetle for example, responds quickly to large scale blowdown, fire scorched trees, or spruce impacted by flooding; which provides both food and breeding material. Large beetle populations can be produced by such breeding material, leading to potential outbreaks. Many of the windthrow in southeast Alaska are not large-scale events but may maintain a pre-outbreak population of spruce beetle.

As agents of disturbance, spruce beetles are one of the most important mortality agents of mature spruce stands in Alaska. There are a variety of impacts associated with outbreaks to forest resources, both timber and non-timber. These impacts can be viewed positively or negatively depending on the forest resource in question. Some of the impacts associated with spruce beetle infestations include, but are not limited to:

(1) Loss of merchantable value of killed trees: The value of spruce as sawtimber is reduced within three years of beetle attack in south-central Alaska as weather checking and increased sap-rots occur. The value of beetle killed trees as houselogs, chips, or firewood continues for some time. ;

(2) Long term stand conversion: To best regenerate both spruce and birch, a site disturbance (i.e. fire, windthrow, flooding, scarification, etc.) is required which results in a seed bed comprised of bare mineral soil with some organic material. If there is adequate seed source, such site disturbances provide excellent sites for regeneration. However, what is occurring on many sites in south-central Alaska after spruce beetles have "opened up" the canopy is a scarcity of regeneration due to minimal ground disturbance. Under such conditions, grass and other competing vegetation quickly

invade the site and delay future re-establishment of tree species.;

(3) Impacts to wildlife habitat: Populations of those wildlife species that are dependent upon live, mature spruce stands for habitat requirements will decline. We expect to see decreases in red squirrel, spruce grouse, Townsend Warblers, and possibly Marbled Murrelet populations. On the other hand, those wildlife species such as moose, small mammals and their predators, etc., that benefit from early successional vegetation such as willow and aspen, may increase as stand composition changes.;

(4) Impact to scenic quality: Recent studies have demonstrated that there is a significant decline in scenic quality of spruce beetle impacted stands and that scenic beauty is an important forest resource. In back-country areas, however, surveys have shown that publics are evenly divided as to whether spruce beetle outbreaks are a problem or not. Along scenic corridors such as National Scenic Byways, maintaining or enhancing scenic quality necessitates minimizing impacts from spruce beetle infestations.;

(5) Fire hazard: There is concern that fire hazard of spruce beetle impacted stands will increase over time as dead trees fall and dry grass accumulates, thus increasing fuel loading. After an outbreak, grass cover in impacted stands increases from less than 5% to more than 50%. Blue-joint grass cover provides a fine, flashy fuel; fire spreads rapidly through this grass because of the large volumes of fine dry litter present in the spring. Also, recent Alaska studies have shown that more than 35 tons per acre of large woody debris accumulates on the forest floor 5-10 years after a spruce beetle outbreak. In contrast, approximately 2 tons per acre of large woody debris accumulates in uninfested stands. Sound wood, which makes up 65% of the total fuel tonnage, is the heaviest component of the fuels complex. They do not readily ignite, but once ignited they burn at higher temperatures for longer periods.;

(6) Impact to fisheries: If salmon spawning streams are bordered by large diameter spruce and if these trees are subsequently killed by spruce beetles, there is a concern as to the long term availability of large woody debris in the streams. A continual supply of large woody debris in spawning streams is a necessary component for spawning habitat integrity.; and

(7) Impact to watersheds: Intense bark beetle outbreaks can kill large amounts of interceptive vegetation. The "removal" of significant portions of the vegetation will impact to some degree, dynamics of stream flow, timing of peak flow, etc. There have been no hydrologic studies in Alaska quantifying or qualifying impacts associated with spruce beetle outbreaks. Impact studies, however, have been done elsewhere. In lodgepole pine stands in Idaho that have been impacted by the Mountain Pine Beetle, a 15-21% increase in water yield; a 2-3 week advance in post-epidemic hydrograph; and a 10-15% increase in higher flows have been documented.

There are a variety of techniques that can be used to prevent, mitigate, or reduce impacts associated with spruce beetle infestations. However, before pest management options can be developed, the resource objective(s) for a particular stand, watershed, landscape, etc. must be determined. The forest manager must evaluate the resource values and economics of management actions for each stand in light of management objectives. The beetle population level must also be considered because population levels

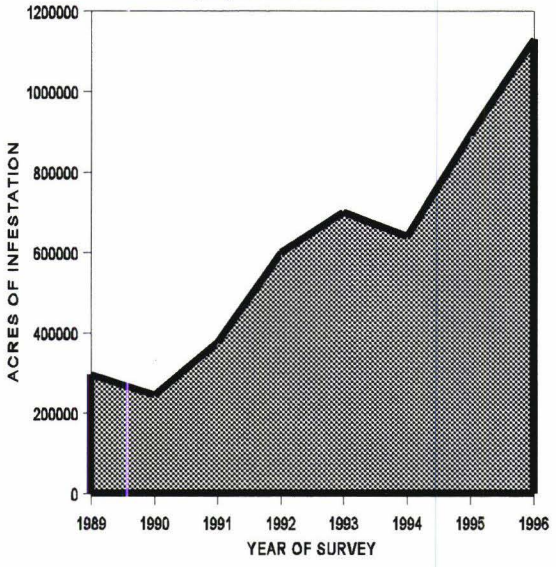
will determine the priority of management actions and the type of strategy to be invoked. Properly applied silvicultural practices as well as fire management in south-central and interior Alaska, can maintain the forest diversity needed to provide the range of products and amenities available in the natural forest.

SPRUCE BEETLE

Dendroctonus rufipennis Kirby

With a 61% increase in the area infested over the past two years (21% in 1996 alone), spruce beetle continues to have the most significant ecological impact of any natural agent of change in Alaska. More than 1.1 million acres of spruce beetle activity were mapped in 1996, the highest level of activity on record.

Chart 1. SPRUCE BEETLE INFESTATION
On-going and new infestations



While spruce beetle activity in interior Alaska white spruce forests rose only slightly (+1,063 acres to 23,346 acres), activity in southeast Alaska's Sitka Spruce forests more than doubled in one year to 35,334 acres. As in 1995, the areas of most intense activity remain the Copper River Basin with 234,581 acres, an increase of 65,000 acres over 1995 levels and the balance in south-central Alaska at 837,499 acres, an increase of almost 20% over 1995 levels. Spruce mortality in many areas of south-central Alaska now exceeds 80%.

Areas of specific interest include:

South-central and Interior Alaska: *Spruce beetle activity in the northern portion of the Kenai Peninsula* rose only slightly (+2,500 acres) this year to a total of 35,000 acres. The incorporation of the most up-to-date GIS layers for land ownership puts the acreage figure for the Chugach National Forest to 14,042 acres. This layer includes the latest State and Borough land selections from within the Forest. The reported figure of 35,000 acres accurately reflects the impacted acres of spruce forest in the northern Kenai Peninsula, which includes the Chugach National Forest, and thus indicates a fairly static population.

Throughout Turnagain Arm, spruce beetle populations continued to intensify. With the exception of one minor decline (<50 acres) in a single area, every area has reported increased activity. Areas of note are: the first report of beetle activity in the Portage River Valley (90 acres); 2,420 acres from Turnagain Pass to the Hope "Y" along the Seward Highway, an increase of 1,175 acres over 1995 levels; spruce beetle activity in the Twenty-Mile River Valley activity increased nearly fourfold from 200 acres in 1995 to 775 acres in 1996; activity in the Six-Mile River drainage continues to escalate with an increase of 647 acres to a total of 2,282 acres. From Sunrise to Hope along Turnagain Arm, beetle-infested acreage's expanded by a factor of ten from 50 acres in 1995 to 496 acres in 1996. Since spruce in this area is confined to narrow stringers separating a series of avalanche

slide zones, this 500 acres of reported impact actually indicates the loss of most of the mature spruce in this eight mile stretch of highway. Finally, in and around Hope, including Bear Creek and Palmer Creek, activity more than doubled from 1,500 acres in 1995 to 3,247 acres in 1996.

In the Trail Lakes/ Moose Pass area, only a very slight increase (233 acres) in activity was observed. Most of the mature spruce in these stands have been lost to beetles over the past several years.

Activity around Kenai Lake, Cooper Lake, Russian Lakes and Russian River has declined rather dramatically. This major decline, over 10,000 acres, is the result of the removal by spruce beetles of almost all susceptible spruce.

The last area of note in the northern Kenai Peninsula are *the stands of Sitka spruce between Lawing and Seward* where beetle activity has increased from 20 acres in 1995 to 1,157 acres in 1996.

Throughout the remainder of the Kenai Peninsula beetle activity has intensified as it has for 8 of the past 10 years (see map in Appendix C). From Pt. Possession south to Tustumena Lake, spruce beetle-impacted acres has increased by more than 33,000 acres to 83,239 acres. Most of these additional impacted areas are, as in 1995, located between Skilak and Tustumena Lakes. Moving south through the Peninsula from Tustumena Lake to Homer, including the Fox River valley at the east end of Kachemak Bay, beetle activity has risen by 20,000 acres to 337,024 acres. On the south shore of Kachemak Bay, from Sheep Creek to Seldovia, 37,940 acres of beetle-infested stands were mapped. This represents an increase of only 2,000 acres over 1995 levels. Most of these 2,000 additional acres occur between Bradley Lake and Sheep Creek at the eastern end of the Bay. To the west, between Bradley Lake and Seldovia, the population is nearly static, though quite intense. West of Seldovia to Port Graham, the rather small, scattered population reported in 1995 has declined by nearly one half to only 645 acres.

Thus, spruce beetle activity as a whole on the Kenai Peninsula, has increased by 53,000 acres to 458,203 acres. Although the total acreage has increased slightly, the rate of expansion overall seems to have slowed considerably most likely due to lack of suitable host material as a result of losses incurred by the spruce beetle over the past ten years. However, we can expect to see increased beetle activity in the Homer and Anchor River areas.

On the west side of Cook Inlet, however, the picture is quite different. The spruce beetle impacted areas continue to expand. (+20%). Of the 85,232 acres of activity noted, 28,336 acres were located in the Tuxedni Bay area, 20,854 acres in the Redoubt Bay area and 35,885 acres throughout the West Forelands.

The infestation in the *Lake Clark Pass area* has declined from 19,000 acres in 1995 to 13,000 acres in 1996. Nearly 100% of the mature spruce in this area has been killed.

Spruce beetle activity continues to intensify in the *Copper, Moose, and Kakhonak Lakes areas and to expand to new areas around Lake Iliamna*, particularly in and around Pedro Bay. 14,759 acres of additional spruce beetle activity were mapped in 1996 for a total of 85,232 acres, a 16% increase over 1995 levels.

In the Anchorage Bowl, the largest urban-wildland interface in Alaska, spruce beetle

activity has nearly doubled for the second consecutive year to 15,310 acres. 40% of the total, over 6,000 acres, occur on the hillside from Potter Marsh to Ft. Richardson. Beetle activity on Ft. Richardson and Elmendorf A.F.B., between the Glenn Highway and Knik Arm, account for another 5,535 acres. The balance of activity is scattered throughout the Anchorage area with a few areas of particular intensity, namely Kincaid Park and Fire Island.

Moving north along the *Glenn Highway toward and through the Matanuska Valley*, acres of spruce beetle-impacted stands continues to rise. Noteworthy areas are: Eagle River valley- up 1,089 acres to 5,760 acres; Eklutna River valley- up 6,074 acres to 8,874 acres and the Knik River valley at 11,365 acres. Throughout the Matanuska Valley, from Palmer to Eureka, spruce beetle activity more than doubled from 24,640 acres in 1995 to 66,635 acres in 1996- a 63% increase. Major expansion of activity occurred primarily between the Chikaloon River and Eureka Summit.

In the area bounded by Tazlina Lake and the Glenn Highway, from Eureka to Glenallen, spruce beetle activity has increased dramatically (see map in Appendix C). In only one year, beetle activity along the Nelchina River rose from endemic levels of <1 tree/acre in 1995 to 8,407 acres of moderate to heavy activity in 1996 and in the Tazlina/Kiana Lakes area activity rose from 545 acres in 1995 to 7,551 acres in 1996, a thirteen fold increase. Moving east to Klutina /St. Anne Lakes, populations continue to rise here as well. Acres impacted by spruce beetles more than doubled from 15,062 acres in 1995 to 36,042 acres in 1996. The only area of decline observed in the Copper River valley occurred along the Richardson Highway between Chistochina and Copper Center where populations fell from 5,426 in 1995 to less than 1,000 acres of active infestations in 1996.

In the mid-Copper River valley, from Copper Center to Chitina, spruce beetle continues to be active, though at lower levels of intensity. This area has been heavily impacted over the past several years and much of the mature spruce has been killed. Large-scale salvage logging by native corporations is underway in these stands. Although an increase of 40,474 acres was noted, much of the activity has been characterized as "light". Further south along the Copper River, between Chitina and the Bremner River, an increase of 3,500 acres was observed. Most of these losses occur in the immediate vicinity of Chitina. Beyond Chitina, the range of spruce, which is restricted by topography to narrow bands along the river, has been severely impacted over the past five years and few live spruce remain. At the confluence of the Bremner/ Little Bremner Rivers, an area not surveyed in 1995, almost 15,000 acres of very intense activity was observed. Mortality approaches 80% throughout these stands. East along the Chitina River to McCarthy, nearly 7,000 acres of new beetle activity were noted. Most of this impact occurs along the Chitina River between Chitina and the Tebay River. In another area of severe impact, nearly 100% of mature spruce in the Tebay Lakes/River drainage have been lost. 1,167 acres of new activity have also been noted in spruce stands to the west of Kennicott Glacier.

In total, 27,000 acres in the Chitina River valley are now being impacted. In the upper Chitina River valley, between the Chitina and Tana Rivers near Towhead Mountain, an area not flown in 1995, 3,000 acres of medium to heavy beetle activity were observed.

Beetle activity throughout the entire Copper River valley, therefore, has increased by 89,111 acres in 1996 for a total of 239,623 acres of on-going or new infestations.

Once again, 1996 spruce beetle activity was noted in widely scattered areas of *interior Alaskan white spruce forests*. However, four areas of activity are worthy of note. The upper Susitna River drainage accounted for 3,497 acres. This on-going infestation is scattered over 50 miles of forest land between the Talkeetna and Kashwitna Rivers in the foothills of the Talkeetna Mountains. The Yukon River infestation, between Kaltag and Koyukuk, rose by less than 500 acres to 7,179 acres in 1996. One area of intensification occurred along the Koyukuk River between Koyukuk and the confluence of the Kateel/Koyukuk Rivers, where 7,512 acres of activity were mapped. The source of this new activity appears to be the infestation at the mouth of the Koyukuk River which has been on-going at a fairly static level since 1988.

Finally, *along the Kuskokwim River*, south from McGrath to Devil's Elbow, the number of beetle-impacted acres rose slightly from 3,000 acres in 1995 to 3,829 acres in 1996. This increase represents more an intensification of activity in areas already impacted rather than an expansion of activity to new areas.

Southeast Alaska:

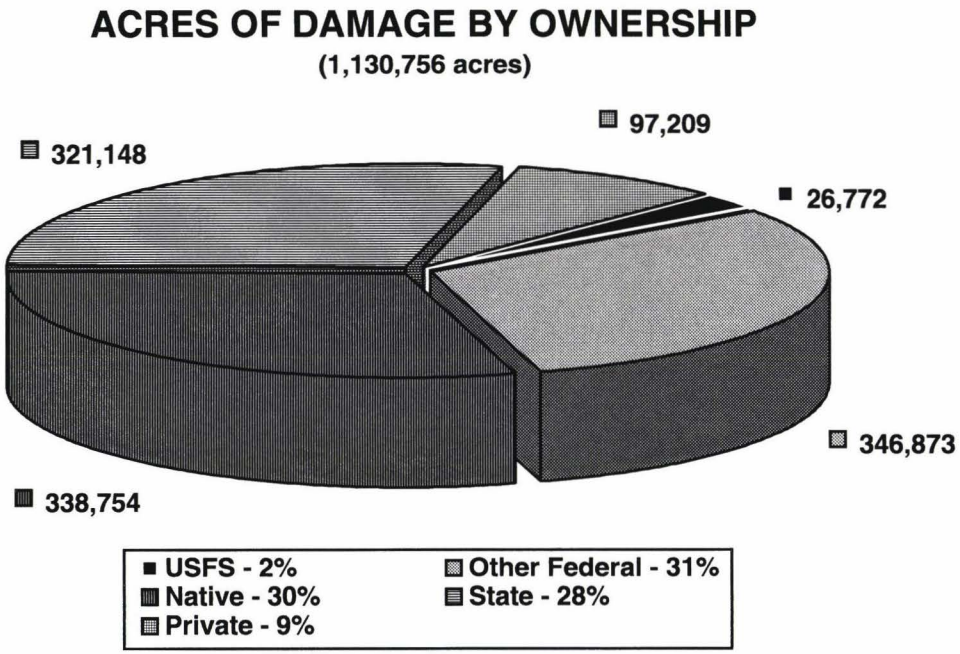
During 1996 in southeast Alaska, spruce beetle infestations encompassed approximately 35,700 acres (see map in Appendix C). Four areas were impacted substantially, although other scattered areas were affected to a smaller degree. The spruce beetle outbreak in Glacier Bay National Park (Figure 1, page 21) has shifted east and up in elevation (1500 ft.) from its historic location in lower Glacier Bay. The historic outbreak in lower Glacier Bay has impacted more than 30,000 acres, resulting in mortality as high as 75 percent from outbreaks over the past decade and a half. The infestation along the west side of the ridge between Gustavus and Excursion Inlet increased to approximately 4,250 acres. Wood rotting fungi, such as *Fomitopsis pinicola*, have rapidly infested beetle-killed trees, resulting in bole breakage and numerous forest canopy gaps. Secondary plant succession follows in these gaps, among the many jackstrawed tree boles and tops. Observations to date on Lester Island indicate a predominance of hemlock regeneration in these disturbed/altered stands.

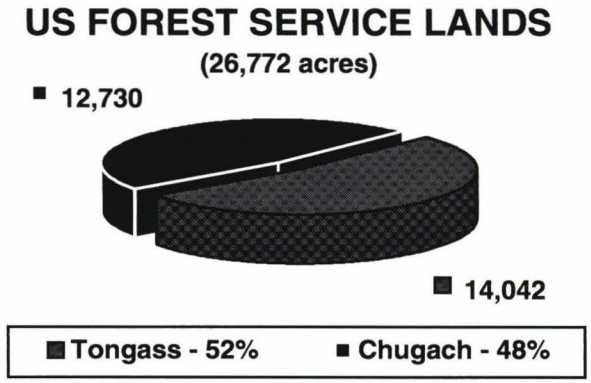
The Haines area experienced the most substantial spruce beetle pressure in southeast Alaska as the outbreak continues for the seventh consecutive year. Over 13,800 acres along drainages of the Chilkat, Klehini, and Kelsall Rivers were new or ongoing infestations, nearly quadrupling 1994 acres. The majority of this area is located on state lands, but the infestation continues north into Canada. Salvage efforts have been increased in the Haines area by State personnel.

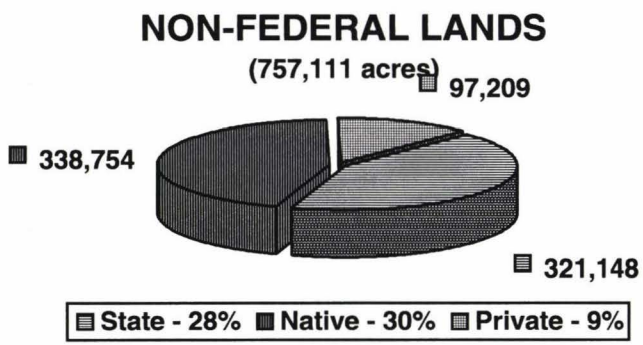
Spruce beetle activity on *islands bordering the Pacific Ocean south of Baranof Island* was first noted in 1996. It could have been detected prior to 1996 if a complete survey of all lands within southeast Alaska had been done. Approximately 9,500 acres of Sitka spruce were infested on Dall, Noyes, Suemez, Baker, San Fernando, LuLu and Cone Islands. Much of the acreage, 6,350 acres, was on Dall Island.

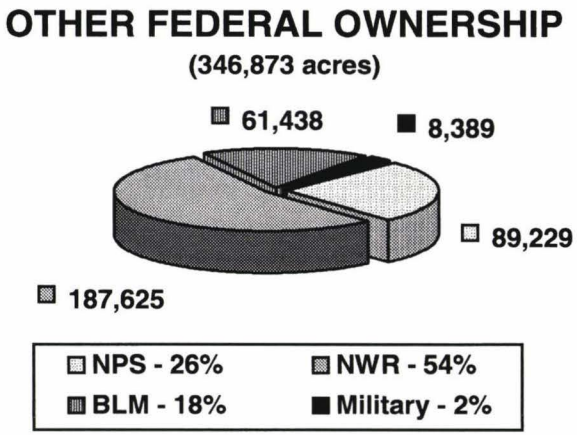
Spruce beetle activity *on National Forest and private land along the Taku River* is in

ACRES OF SPRUCE BEETLE DAMAGE BY OWNERSHIP - 1996









its third year and has shown an increase in active infestation, from approximately 75 acres in 1994 to 3,900 acres in 1995 and 4,850 acres in 1996. This beetle activity follows a large windthrow event that occurred in the fall of 1990. The beetle effects this year were compounded by heavy black-headed budworm defoliation in the same area. Reports of new windthrow events should support a continued expansion of this outbreak.

Spruce beetle activity continues to increase in the *Stikine River delta area*, including Dry Island, Farm Island, Rynda Island, Sokolof Island, Kadin Island, Sergief Island, Greys Island, and Pocket Island. There was only an increase of 250 acres over 1995 levels of 2,040 acres. Scattered, small scale spruce beetle activity occurred throughout Prince of Wales Island, north Kuiu Island, north Chichagof Island, Yakutat Forelands, and west side of Admiralty Island.

ENGRAVERS

Ips perturbatus Eichh.
Ips tridens Mann.
Ips conncinnus Mann.

Three species of *Ips* beetles are currently causing spruce mortality. *I. perturbatus* is found primarily in Interior Alaska and often causes mortality in white spruce. *I. tridens* is found throughout Alaska and western Canada but is generally not considered economically important because adults usually attack only weakened, windthrown, felled trees, or slash. *I. conncinnus* is the most common species in southeast Alaska's Sitka spruce. A visual indication of *Ips* infestation in spruce is that all needles turn red usually beginning at the top of the tree progressing down as compared to spruce bark beetle where the needles turn red usually starting from the bottom.

Interior Alaska

Engraver activity in interior Alaska increased to 13,274 acres in 1996, up from 5,621 acres in 1995. Although a 250% increase in affected acres in one year appears quite large, *Ips* beetle populations have historically fluctuated dramatically in response to both natural and human-caused activities which provide suitable breeding material for the beetle. *Ips* outbreaks in interior Alaska are often associated with timber harvesting, road building, drought stress, riverbank erosion, flooding and windthrown timber.

The Christian/Sheenjek Rivers infestation, which in 1995 accounted for nearly half of the total *Ips* activity observed in interior Alaska, has declined by more than 1,000 acres to 1,439 acres in 1996.

Ips activity in the Yukon Flats region of the upper Yukon River, from Circle to Stevens Village, continues at a pace fairly typical of this area. 891 acres of *Ips* activity were mapped in 1996.

Downriver from Stevens Village to Tanana, another 2,443 acres of *Ips*-caused spruce mortality were observed. Southwest of Fairbanks, along the Tanana River between Fairbanks and Nenana 1,100 acres of *Ips* beetle impact were mapped. Further west, in an area heavily impacted by both *Ips* beetle and the spruce beetle in the late 1980's, 6,211 acres of *Ips* (combined with spruce beetle) activity were noted. In 1989, this area of the Yukon River, between Nulato and Kaltag, accounted for 140,000 acres of beetle-caused mortality. In 1990, ground checks indicated that *Ips* beetles

were probably as important as spruce beetles in carrying this infestation along.

In the Kuskokwim River drainage, *Ips* continues to impact stands along the North Fork of the Kuskokwim River. 453 acres of spruce mortality were observed between Medfra and Wilson Hill in 1996.

South-central Alaska

Spruce stands bordering the Seward Highway near the entrance to Granite Creek Campground have come under heavy spruce beetle attack. About three years ago, National Forest personnel developed prescriptions to mitigate the losses attributed to the bark beetle by removing infested trees and thinning the stand in order to increase residual stand vigor. From a site visit in 1996, it became apparent that some of the residual spruce had been attacked by *Ips*, probably *I. tridens*. Approximately 18% of the residual spruce had been killed. It is anticipated that *Ips*-caused tree mortality will continue but at a declining rate.

Southeast Alaska

In southeast Alaska Ips infested trees were isolated to several dense, immature stands, from Prince of Wales Island to Haines, totaling approximately 400 acres. The only ongoing activity, on Chilkoot Lake near Haines, has decreased to approximately 70 acres and is a combination of spruce bark beetle and *Ips* beetle.

SPRUCE BUDWORM
***Choristoneura* spp.**

White spruce defoliation in interior Alaska attributed to the eastern spruce budworm declined by 15% (43,335 acres) in 1996; 235,936 acres of defoliation were observed. The level of intensity, however, remains quite high throughout its range. Downriver along the Yukon River, from Tanana to Ruby, 144,571 acres of budworm activity were detected; upriver, from Tanana to Rampart, 15,180 acres and from Rampart to Steven's Village, 8,847 acres were observed. The infestation in the Nenana Ridge/Goldstream Valley near Fairbanks increased 6,150 acres to 16,815 acres in 1996. (Figure 2, page 21)

It appears the infestation is slowly expanding westward along the Yukon River. Most areas of activity in 1996 remain at fairly static levels compared to 1995; however, two areas have undergone substantial change. On the western front of the infestation, near the confluence of the Nowitna and Yukon Rivers, populations nearly doubled from 39,129 acres in 1995 to 74,936 acres in 1996. This increase was offset by a 50% decline in the acreage infested near the confluence of the Tanana and Yukon Rivers where 65,888 acres of spruce budworm activity were observed in 1996 compared to 129,534 acres in 1995. The Big Delta area, which reported 13,359 acres of spruce budworm impact in 1995, was not flown in 1996.

Concern has been expressed in the past that endemic engraver (*Ips* beetle) populations may take advantage of these trees stressed by six consecutive years of spruce budworm defoliation. This now appears to be the case in the Rampart to Steven's Village portion of the outbreak where 2,614 acres of *Ips* beetle activity was observed throughout the same stands impacted by spruce budworm.

SPRUCE CONEWORM

Dioryctria reniculelloides Muturra & Munroe

Spruce coneworms are members of the Pyralidae family and usually have one generation per year in Alaska. The larvae are commonly mistaken for spruce budworms. Coneworm larvae attack and feed on developing spruce cones as well as mining and feeding on buds and expanding shoots. Populations of budworms and coneworms are often found on the same tree. As previously mentioned, some of the massive spruce budworm outbreaks in interior Alaska may be due to coneworm feeding. Coneworm defoliation was also quite apparent on ornamental blue spruce throughout the Anchorage area.

WESTERN BLACK-HEADED BUDWORM

Acleris gloverana Walsingham

The black-headed budworm is native to the forests of coastal and southwestern Alaska. It occurs primarily in southeast Alaska and has been documented there since the early 1900's. Budworm populations in Alaska have been cyclic, arising quickly, impacting vast areas, then subsiding within a few years.

In southeast Alaska, western hemlock is the budworm's preferred host, but Sitka spruce and Mountain hemlock are also fed upon. The overall ecological role of the black-headed budworm in Alaska's forests is not known. However, many aspects of the budworm's role are known and several inferences can be made from available information.

Repeated years of budworm defoliation may cause growth loss, top-kill and in severe cases, death of the host. Heavily defoliated trees may also be more susceptible to other mortality agents. As a major forest defoliator, black-headed budworm can ultimately influence both stand composition and structure. To the extent that defoliation reduces overstory crown density (through crown thinning or tree death), less shade tolerant understory plants may become established. Such habitats favor small mammals, deer, predacious and parasitic insects, and some insectivorous bird species. By consuming needles and depositing nutrient-rich fecal material on the forest floor, budworm larvae are also accelerating nutrient cycling processes. Recent investigations by the Pacific Northwest Research Station indicate that terrestrial insect larvae, such as budworm, may be a larger portion of the diet for some species of salmon fry than were previously understood, especially during outbreak periods.

The peak year for budworm defoliation occurred in 1993, totaling 258,000 acres of defoliation. Cool wet weather in early summer months retard growth and development of the budworm. This climatic condition in 1994 may have resulted in population declines.

Black-headed budworm populations crashed in 1995. The last budworm outbreak of this magnitude occurred from the late 1940's to the mid-1950's. The 1995 budworm defoliation occurred on approximately 13,000 acres, significantly down from the 193,000 acres recorded in 1994. There were only 550 acres of activity detected in southeast Alaska in 1996.

Approximately 100 acres of light defoliation occurred along Peril Strait west of Florence Bay and northwest of Pavlof Harbor in Freshwater Bay, Chichagof Island. There were 100 acres of defoliation along Eagle River, north of Juneau; 50 acres (light defoliation) on the west side of Princess Bay, Revillagigedo Island.

From 1992 to 1994 the numbers of larvae sampled were consistently higher north of Frederick Sound, however in 1995 and 1996 the opposite was true. The defoliator plots south of Frederick Sound produced a greater average budworm per branch then did the areas northward. The greatest numbers of larvae were collected from Cholmondeley Sound, Prince of Wales Island.

Black-headed budworm activity was noted in two areas in Prince William Sound. One spot north of Bering Lake and east of the Copper River Delta and the other north of Coghill Lake along the College Fiord for a total of 676 acres. It is expected that budworm populations will continue to remain low in 1997.

HEMLOCK SAWFLY

Neodiprion tsugae Middleton

Hemlock sawflies are common defoliators of western hemlock and are found throughout southeast Alaska. Historically, sawfly outbreaks have been larger and of longer duration in areas south of Frederick Sound.

Unlike the larvae of the black-headed budworm, hemlock sawfly larvae feed in groups, primarily on older hemlock foliage. The two species of insects feeding in combination have the potential to completely defoliate western hemlock. Heavy defoliation of hemlock by sawflies is known to cause reduced radial growth and top-kill. As forest defoliators, hemlock sawflies may ultimately influence both stand composition and structure in some areas. The sawflies themselves are a food source for numerous birds, other insects, and small mammals.

In southeast Alaska, there have only been a few acres of sawfly defoliation of western hemlock since 1994. There has been an increase from 1,100 acres of defoliated trees in 1995 to 8,250 acres of defoliation in 1996, although most of the defoliation was classified as light.

The defoliation in 1996 occurred throughout southeast Alaska but closer to the mainland then the Pacific Ocean. On Admiralty Island west of Mole Harbor, 1,600 acres were lightly and 700 acres were moderately defoliated. Also, one 500 acre area east of Mole Harbor on the Glass Peninsula of Admiralty Island was defoliated. On the southeast tip of Mitkof Island 1,600 acres were defoliated. A total of 1,000 acres of defoliation was detected primarily around the West Arm of Cholomondeley Sound, an area where defoliation has occurred historically.

The highest hemlock sawfly larvae counts were from defoliator plots south of Frederick Sound, particularly at Calder Bay, Prince of Wales Island. Many of the highest counts occurred throughout Prince of Wales Island.

SPRUCE NEEDLE APHID

Elatobium abietinum Walker

Spruce needle aphids feed on older needles of Sitka spruce, often causing significant amounts of needle drop (defoliation). Aphid defoliation causes reduced tree growth and often predisposes the host to other mortality agents, such as the spruce beetle. Likewise, severe cases of defoliation alone may result in tree mortality. Spruce under stress, such as those in urban settings and those along marine shorelines, are most seriously impacted. Spruce aphids feed primarily in the lower, innermost portions of tree

crowns, but may impact entire crowns during outbreaks. Spruce aphid outbreaks in southeast Alaska are usually preceded by mild winters.

Following the mild winter of 1991-92, spruce needle aphid populations in southeast Alaska expanded rapidly, causing over 25,000 acres of Sitka spruce defoliation. Needle aphid populations crashed in 1993, due to extended periods with sub-freezing temperatures during January and February. After a slight resurgence of activity in 1994, the 1995 population levels were low. In 1996, 255 acres of activity occurred at the mouth of Antler River, Berner's Bay, 126 acres above the town of Sitka, 50 acres along the northeast shore of Connell Lake, Revillagigedo Island, 14 acres near the south end of Russell Fiord near Yakutat, 24 acres on the north end of Pennock Island, and 5 acres at Saginaw bay, Kuiu Island for a total of 474 acres. The relatively low number of acres in 1996 may be due to the proceeding colder than average winter.

LARGE ASPEN TORTRIX

Choristoneura conflictana Wlkr.

Large aspen tortrix defoliation decreased 80% from 32,347 acres in 1995 to 6,489 acres in 1996. Tortrix populations are scattered throughout south-central and interior Alaska wherever their host species, aspen, is found. For example, 843 acres were noted on the Koyukuk River at Twentyfive Mile Cabin, 539 acres were noted on the Kenai Peninsula near Soldotna, and 210 acres on the Yukon River east of Ruby. Most defoliation was light to moderate with the largest concentrations being along the Matanuska River near Sutton and along the Susitna River near Willow.

Generally, these caterpillars strip the aspen of their foliage in early spring. However, aspen produce more leaves later in the summer thus very little damage occurs to healthy trees. Stressed trees may decline after several consecutive years of heavy defoliation. Tortrix populations are expected to remain low in 1997.

CONIFER DEFOLIATION

In Prince William Sound, 1,407 acres of conifer defoliation were noted. There was a 980 acre spot near Bering Lake west of Bering River and three spots west of Icy Bay totaling 89 acres. The other area of note was Montague Island; four spots in Sitka spruce totalling 338 acres from Hanning Bay south to MacLeod Harbor on the west side of the island. The causal agent was most likely Black-headed budworm but was not verified.

BIRCH DEFOLIATION

3,179 acres of defoliated birch were mapped in south-central and interior Alaska in 1996. Although defoliation of birch in these areas is often attributed to spear-marked black moth activity, it in fact can be caused by a variety of insect pests.

Insect activity on birch, which from the air appear to be discoloration, crown-thinning or defoliation, can be caused by a variety of insects including aphids, sawflies, leafrollers, loopers or leaf beetles. At times, outbreaks of insects affecting birch have reached astounding levels such as five million acres in the 1950's or 2.5 million acres in the 1970's, both were attributed to spear-marked black moth defoliation. However, in

recent years, birch defoliation has been confined to much smaller areas.

In 1996, 1,722 acres of insect-impacted birch were observed along the north coast of the Gulf of Alaska between Yakutat and the Bering Glacier and 1,126 acres were detected across the Yukon River from Ruby, at the mouth of the Melozitna River. The remaining 330 acres of insect-impacted birch mapped in 1996 occurred in widely scattered areas across the state and in patches of 50-100 acres. If defoliation is apparent again in 1997 along the Yukon River or on the Gulf coast, ground checks will be attempted to determine causal agents. Ground checks of aerially detected defoliation are often difficult due to lack of suitable landing sites. Drought-like conditions in interior Alaska in 1996 precluded landing on even the largest rivers.

COTTONWOOD DEFOLIATION

***Chrysomela* sp. and *Lyonetia* sp.**

Defoliation of cottonwood by leaf beetles (*Chrysomela* sp.) and leaf miners (*Lyonetia* sp.) is common throughout much of the host's range in Alaska. Defoliation is most pronounced near the tops of affected trees, causing the trees to become unsightly. Defoliation is believed to cause reduced tree growth. The biology and overall ecological significance of leaf beetles (*Chrysomela* sp.) in Alaska is not well known.

In southeast Alaska, cottonwood defoliation decreased from 1,700 acres in 1995 to 413 in 1996. Most of the defoliation occurred in the Yakutat Forelands.

Cottonwood defoliation was more noticeable in south-central and interior Alaska this year; approximately 6,100 acres as compared to 1,000 acres in 1995. The largest pockets of defoliation in the interior were 1,882 acres on the Koyukuk River near Roundabout Mountain, 905 acres between Ruby Slough and the Yukon River west of Ruby, and a 577 acre spot on the Yukon River west of Galena. In south-central Alaska, the largest area of defoliation was approximately 400 acres on the Skwentna River west of Skwentna. Other areas of defoliation were found at the head of Eklutna Lake and the Knik River near Pioneer Peak. Cottonwood beetles were noticeable in the urban areas around Anchorage.

HARDWOOD DEFOLIATION

The only hardwood defoliation, other than that affecting cottonwood, birch, and aspen in south-central and interior Alaska, was observed to be impacting alder. This relatively small patch, 602 acres, occurred along the Tanana River between the mouth of the Little Delta River and Birch Lake. The causal agent is unknown.

WILLOW DEFOLIATION

Beginning in 1991, an outbreak of the willow leaf blotchminer, *Micrurapteryx salicifolliela* (Lepidoptera:Gracillaridae) occurred for hundreds of miles in the Yukon and Kuskokwim River drainages. Larvae of this miner cause blotches that result in a yellow or reddish discoloration of foliage easily visible from the air. The outbreak peaked in 1992 at 150,000 acres then decreased over the next 3 years to approximately 5,600 acres in 1995. This year showed a marked increase to 50,265 acres. This insect displays profound host

specificity; some intermingled willow species are free of it while others may be severely infested.

Similar to previous years, defoliation occurred in interior Alaska; the largest areas of defoliation were over 44,500 acres along the Yukon and Porcupine Rivers. On the Yukon River, pockets of defoliation were found from Ft. Hamilton to approximately 20 miles east of Ft. Yukon, nearly 150 air miles. Approximately 13,000 acres of willow defoliation also follows the Porcupine River from the confluence with the Yukon River 58 miles upstream to John Herberts Village.

Of concern though, was what appeared to be large areas of willow mortality along the Yukon River from its confluence with the Porcupine River downstream. This is one of the areas previously defoliated for many consecutive years. Ground inspection of the "mortality" was not possible last year due to low water levels but will be attempted this year. If willow mortality is verified, it may have an adverse impact on local moose populations which are highly dependent upon willow sprouts as a food source.

LARCH SAWFLY

Pristiphora erichsonii (Hartig)

We anticipated a dramatic reduction in larch sawfly activity in interior Alaska in 1996. Sawflies overwinter as pupae in papery cocoons in the forest floor. The winter of 95/96 was extremely cold and there was very little insulating snow cover. Heavy winter mortality was expected; however, just the opposite occurred. Conservatively, more than 600,000 acres of heavy defoliation was observed in 1996 vs. 116,000 acres of defoliation noted in 1995. Almost every larch from Fairbanks to McGrath between the Tanana and Kuskokwim Rivers were completely defoliated. (Figure 3, page 21)

A ground check of heavily defoliated areas near Fairbanks noted a re-flushing of new growth later in the growing season. This is the fourth consecutive year of heavy defoliation in many areas of the interior. Concern still exists that we may see a build up of the larch beetle (*Dendroctonus simplex*) in heavily defoliated areas which could result in heavy mortality of larch over expansive areas.

SPRUCE BUDMOTH

***Zeiraphera* sp.**

Only one 390 acre area of budmoth- caused light Sitka spruce defoliation was detected this year. This spot was located on the Gulf of Alaska side of Glacier Bay National Park and Preserve between Lituya Bay and Palma Bay north of Cross Sound. The budmoth feeding results in dead buds, typically with the bud scales and the current year's dead needles remaining on the shoots.

GYPSY MOTH

Lymantria dispar (L.)

The European gypsy moth was accidentally introduced into Massachusetts from Europe in 1869 and the rest is history! Since then, the gypsy moth has been responsible for considerable damage to the hardwood forests of the eastern United States. Millions of dollars are spent annually attempting to reduce the amount of damage and restrict the distribution of this important forest pest. The European gypsy moth also

arrived in the western U.S. in the early 1980's.

Historically, there has been little gypsy moth activity in Alaska. In 1985, several larvae were detected by moving company employees on lawn furniture which had been shipped to Juneau from the East Coast. Every summer since 1986, USDA Forest Health Protection personnel along with Alaska Cooperative Extension and the USDA Animal and Plant Health Inspection Service have placed pheromone monitoring traps throughout Alaska, especially in locations frequented by out-of-state vehicles, including campgrounds and port areas. To date, only two male European gypsy moths have been trapped; one in a campground near Anchorage in 1987 and the other in a campground near Fairbanks in 1992.

Due to the recent detection of the Asian gypsy moth, a much more damaging race of the European gypsy moth, in the Pacific Northwest, the Alaskan pheromone trapping program was expanded last year; more than 200 traps were placed throughout Alaska from Petersburg to Nome, including Dutch Harbor in 1996. No Asian or European gypsy moths were encountered. If the Asian gypsy moth becomes established in the western U.S., including Alaska, the potential impacts to forests and riparian areas could be tremendous. The trapping program will be carried out again next year.

SPEAR-MARKED BLACK MOTH

Rheumaptera hastata (L.)

For the third year in a row, little or no black-moth activity was observed. Populations typically flare up about every 10 years, defoliate large areas of birch, alder, or willow and are checked by parasites, predators, disease or weather. Populations are expected to remain at low levels in 1997.

SITKA SPRUCE WEEVIL

Pissodes strobi Peck

A number of adult Sitka spruce weevils were collected in 1995, in the Anchorage Bowl, on imported nursery stock (*Picea pungens*). These adult weevils had successfully overwintered as the infested nursery stock was transported to Alaska in the summer of 1994. Infested tree-branch leaders and adult weevils (Figure 4, page 21) were found in the summer of 1996 by Cooperative Extension Service Integrated Pest Management Technicians in a large landscape planting of spruce in south Anchorage. It is not known, however, if the infested material encountered in 1996 was recently brought into the State or the infested leaders are an indication of an established population. It is believed the former is the case as there are not adequate spring/summer temperatures in Alaska to allow for successful brood development. However, if the latter is true, the Sitka spruce weevil could become a serious pest of ornamental and native spruce in Alaska.

CARPENTER WORMS

Prionoxystus robiniae (Peck)

A sample of large lepidopteran larvae was received by Forest Health Protection personnel in the spring of 1996. These larvae had been collected from the lower stems of small (1-4" dbh) black cottonwood and Sitka alder near the Lowe River, Valdez, Alaska. A preliminary identification has been made: *Prionoxystus robiniae* (Lepidoptera:Cossidae). Members of the

Carpenter Worms, cont.

Cossidae family are medium to large moths and are commonly referred to as carpenter worms. Larvae are hairless, vary in color from reddish pink to white except for the dark brown head and light brown thoracic shield. Larvae excavate large galleries in branches, trunks, and roots of many hardwoods. Mature larvae of carpenter worms can reach 50-75 mm in length. To our best knowledge, this is the first time members of Cossidae have been recorded in Alaska. *P. robiniae* has been collected on poplar in the Yukon Territory, Canada.

Carpenter worms are a native of North America and are widely distributed throughout the United States and southern Canada. Hosts include oak, elm, willow, poplar, ash, box elder, black locust, sugarberry, sycamore, and in Alaska, alder. Life cycle is 1 to 2 years in the south and 2 to 4 years in the north. Damage to large trees is in the form of lumber defect. Degrade from carpenter worm damage has been estimated at 15% of the value of rough sawn oak lumber. Infested trees are seldom killed, but young trees, honeycombed by several generations of carpenter worms, may be broken off by wind or flooding. This latter type of damage (tree failure) is commonly encountered throughout the Lowe River flood plain in Alaska. Many heavily stocked areas of early successional species of alder and cottonwood are being dramatically thinned out due to the actions of this borer.

Little is known concerning the biology, life cycle, and population dynamics of this borer. More ground evaluations are planned for next summer. Pheromone traps will be used to collect adults which are needed for final species determination.

BLACK SPRUCE DAMAGE

Red needles that may indicate mortality or defoliation were noticed in twelve black spruce stands, approximately 318 acres. Most of these spots were located at higher elevations. If this is mortality, it is most likely due to an insect such as the *Ips* beetle or to an abiotic condition such as low water levels; black spruce are susceptible to changes in their moisture regime. If these damaged trees are defoliated, it may be due to *Zeiraphera*. Ground verification was not attempted. These spruce will be aerially monitored in 1997.

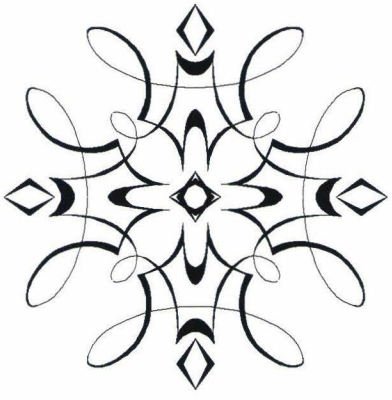


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Figure 1. Spruce bark beetle mortality in Glacier Bay National Park, southeast, Alaska

Figure 2. Close-up of spruce budworm damage on white spruce.

Figure 3. Larch sawfly infestation near Fairbanks, Alaska.

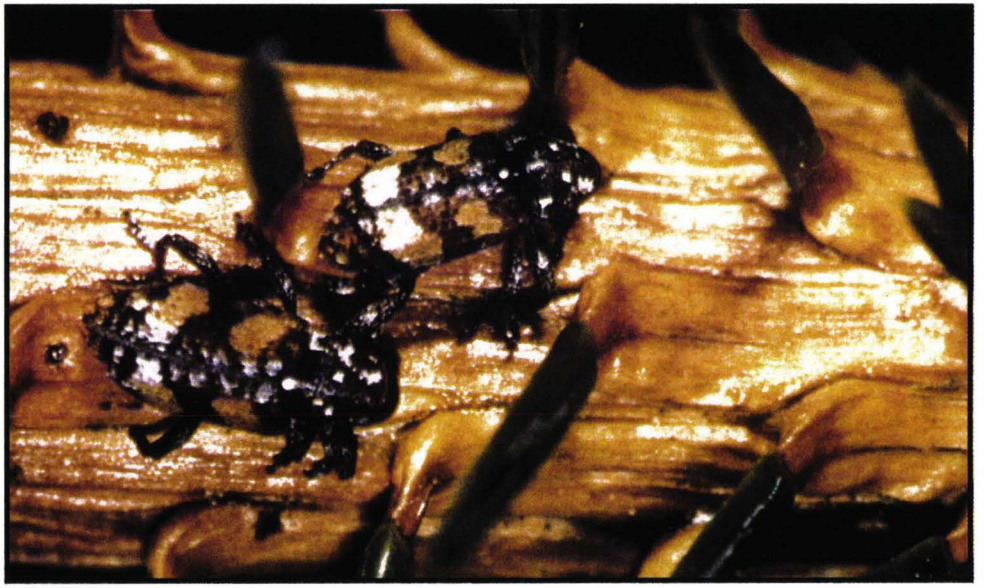
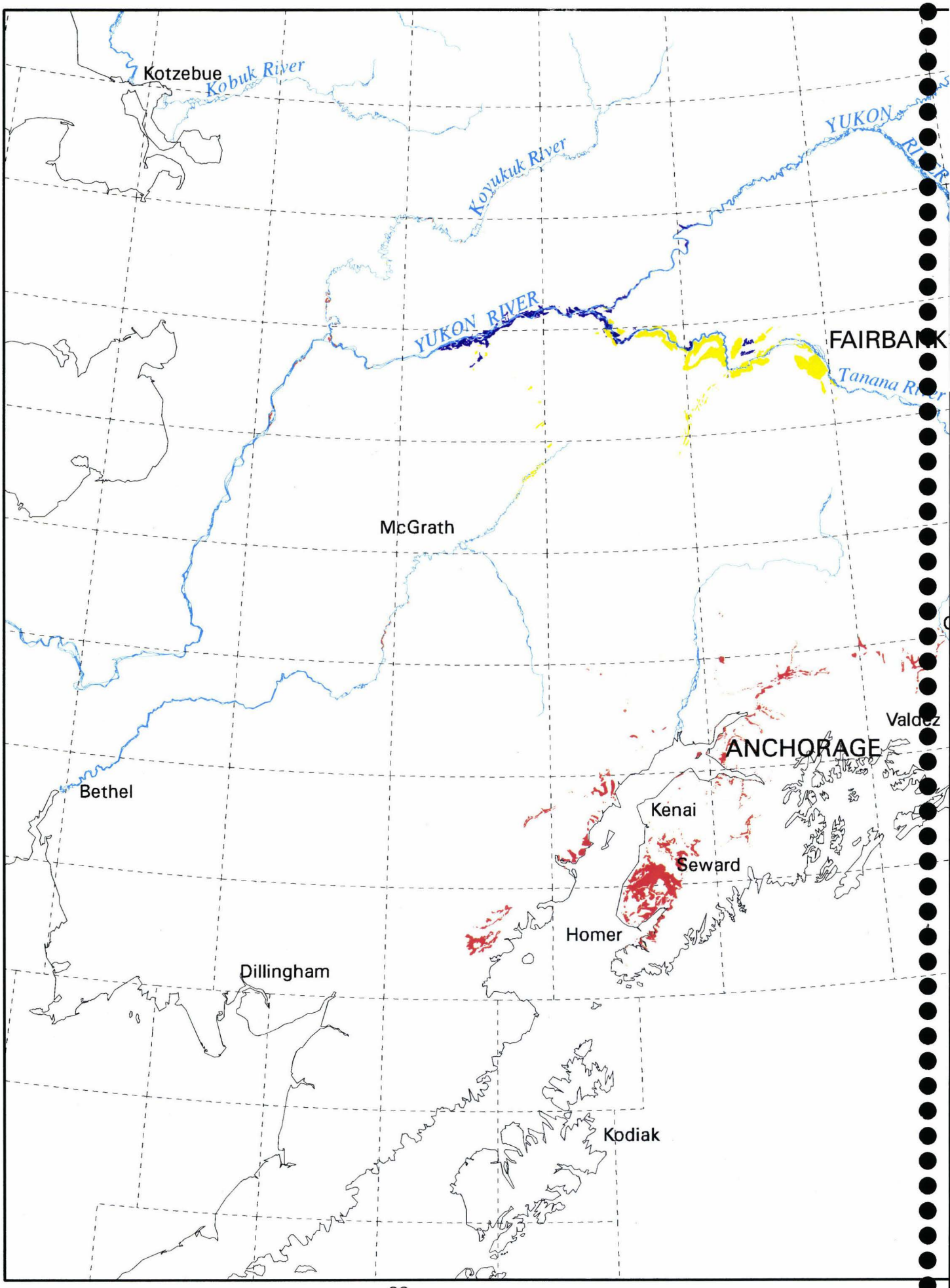


Figure 4. Recently introduced Sitka spruce weevil can damage ornamental spruce.


Kotzebue
Kobuk River
Koyukuk River
YUKON RIVER
YUKON RIVER
FAIRBANK
Tanana R
McGrath
Valdez
ANCHORAGE
Bethel
Kenai
Seward
Homer
Dillingham
Kodiak

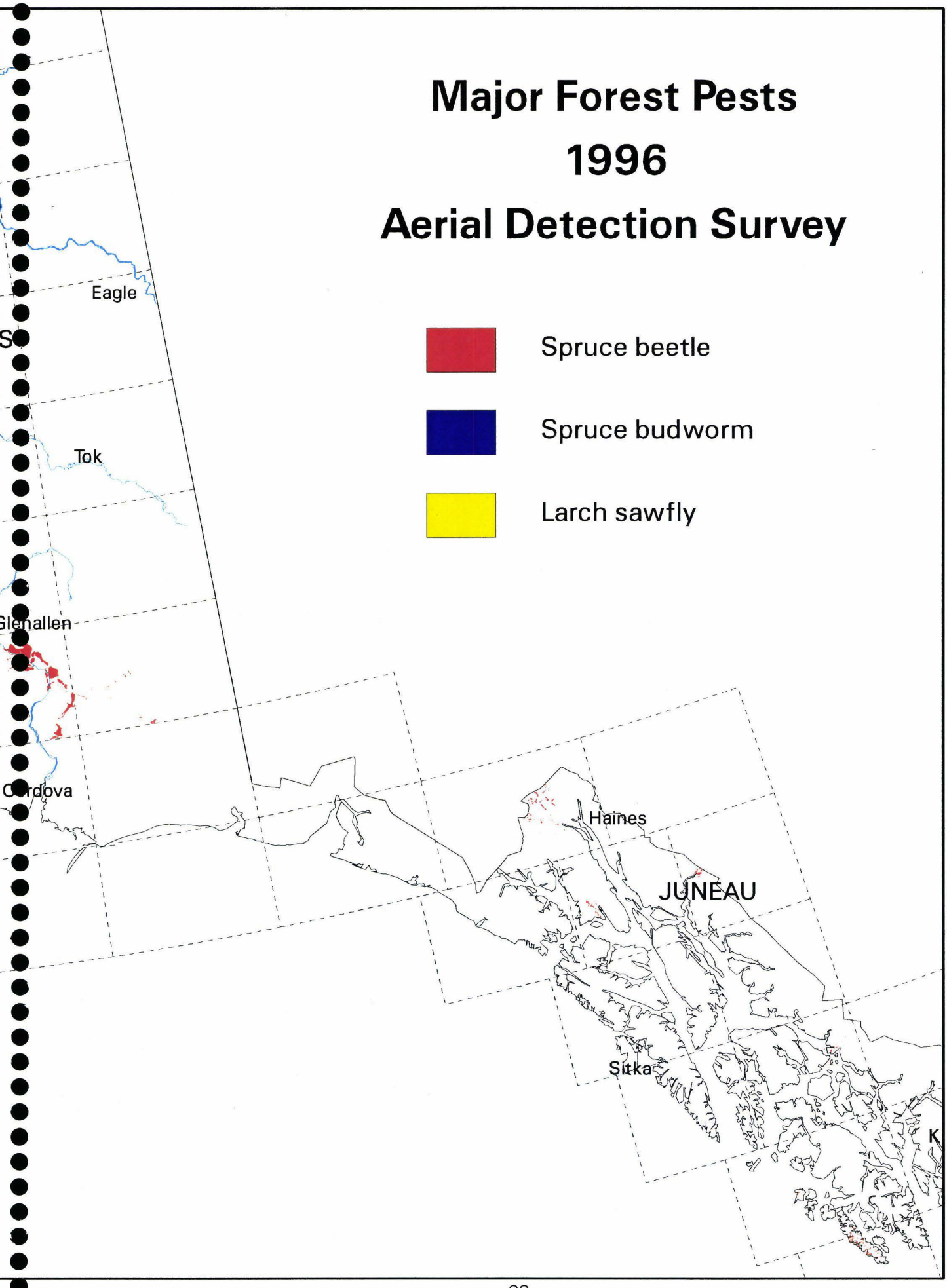

Major Forest Pests
1996
Aerial Detection Survey
Spruce beetle
Spruce budworm
Larch sawfly
Eagle
Tok
Haines
JUNEAU
Sitka

Figure 6. Brooming caused by Hemlock Dwarf Misletoe, *Arceuthobium tsugense.*

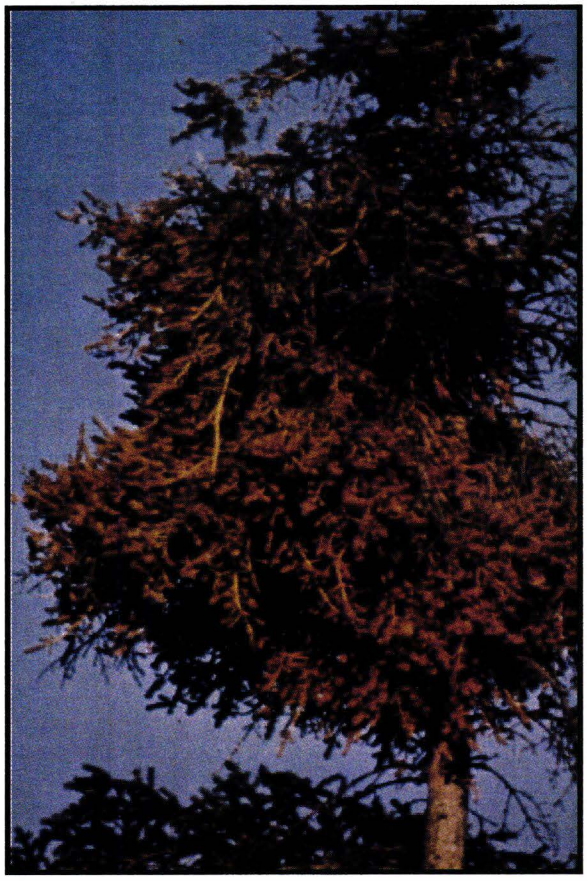


Figure 7. Witches broom caused by spruce broom rust, *Chrysomyxa arctostaphyli.*

Figure 8. A Target-shaped canker on paper birch caused by *Nectria galligena.*

Figure 9. Yellow-ceder decline in southeast Alaska.

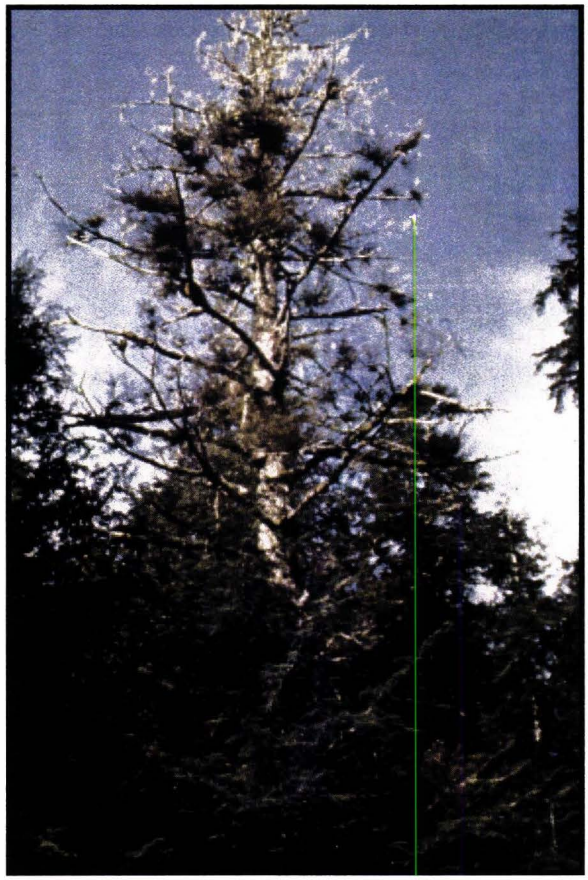


Figure 6. Brooming caused by Hemlock Dwarf Misletoe, *Arceuthobium tsugense.*

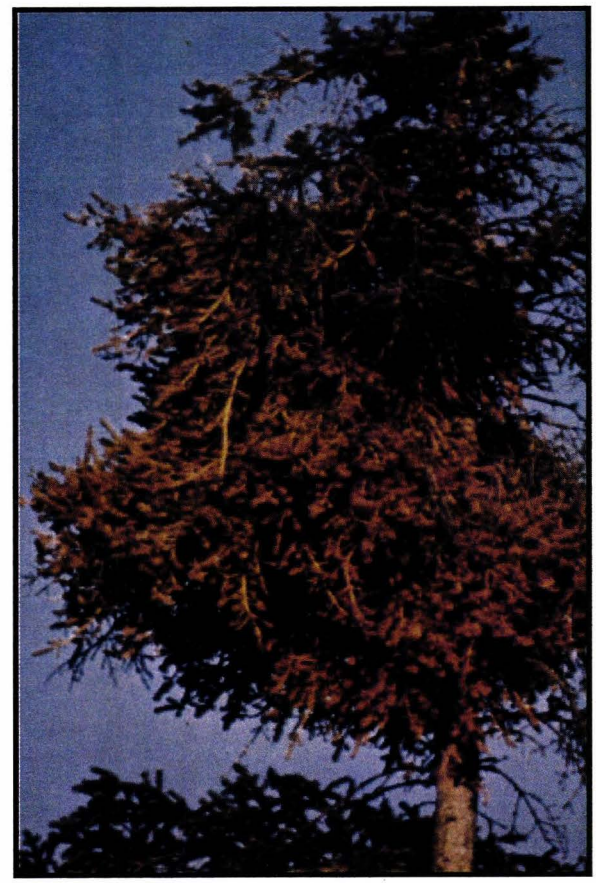


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Figure 8. A Target-shaped canker on paper birch caused by *Nectria galligena.*

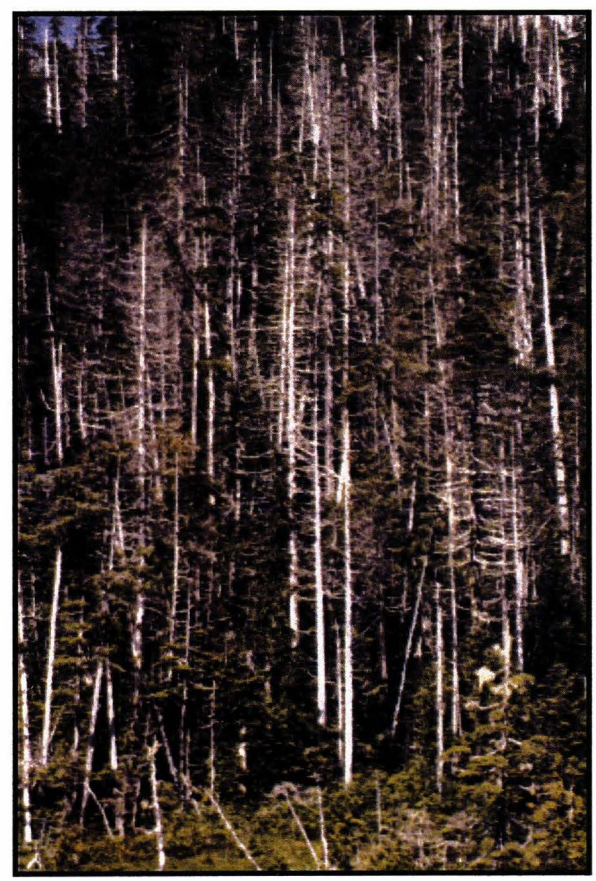


Figure 9. Yellow-ceder decline in southeast Alaska.

STATUS OF DISEASES

ECOLOGICAL ROLES OF FOREST DISEASES

The economic effects of forest diseases in Alaska have been recognized for some time. The nearly ⅓ cull in old-growth forests of southeast Alaska caused by heart rot fungi, for example, has been viewed as a severe limitation on the availability and cost of harvesting timber. The aim of management was to eliminate or reduce disease to minimal levels. But this perspective ignores the functional ecological roles of disease in Alaska's forest ecosystems. We are learning that several key diseases enhance diversity, provide wildlife habitat, and alter forest structure, composition, and succession. As agents of succession in the western hemlock/Sitka spruce communities, diseases are apparently responsible for the "breaking up" of even-aged stands as they are in transition (i.e., 150 to 200 years old) to old-growth phase, and then appear to be the primary factors that maintain the old-growth phase through small scale (canopy-gap) level disturbance. Thus, diseases are key ecological factors in Alaskan ecosystems.

To reduce disease to minimal levels in all instances is to diminish the various desirable characteristics that they produce and to alter successional patterns. Disease control may lead to simplified, homogeneous conditions that are not desirable for many resources. In some cases, uniform forests lacking endemic disease may be more susceptible to epidemics of other organisms. On the other hand, overly abundant levels of some diseases negatively affect nearly all resources. For example, hemlock dwarf mistletoe can build to excessive levels in stands that lack disturbance, resulting in canopy collapse through a process of retarded height growth of all overstory trees. Thermal cover, and vertical diversity are altered so that even resources such as habitat for most wildlife is reduced.

Two of the principal types of disease that alter forest structure in Alaska, heart rot and dwarf mistletoe, can be managed to predictable, desirable levels. If reducing disease to minimal levels is a management objective then both can be largely eliminated for many decades or centuries by clearcut harvesting. Managers need to consider, however, that these organisms can take a long time to recolonize clearcut sites, especially for hemlock dwarf mistletoe. If structural and biological diversity are included as objectives for management, then desirable levels of disease can be attained through different strategies of selective harvesting. Most heart rot in coastal stands is associated with natural bole scars and top breakage. Levels of heart rot can be manipulated by controlling the incidence of bole wounding and top breakage during stand entries. Levels of dwarf mistletoe can be manipulated through the distribution, size, and infection levels of residual trees that remain after alternative harvests. Our ongoing research indicates that the incidence and effects of these diseases will vary through time in a predictable manner by whatever silvicultural scheme is used. One of our objectives in ecosystem management is to develop the tools for managing moderate disease levels that will conserve essential ecosystem processes, enhance many resource values but also maintain productivity of the timber resource.

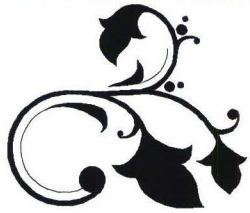


TABLE 2. Suspected effects of common diseases on major ecological characteristics and processes in Alaskan forests. Effects by each disease or disorder are qualified as: - = negligible or minor effect, + = some effect, ++ = dominant effect.

	ECOLOGICAL FUNCTION ALTERED			
DISEASE	STRUCTURE	COMPOSITION	SUCCESSION	WILDLIFE HABITAT
STEM DISEASES				
Dwarf mistletoe	++	+	+	++
Hemlock canker	-	+	-	+
Hardwood cankers	+	+	+	-
Spruce broom rust	+	-	-	++
Hemlock bole fluting	-	-	-	+
Western gall rust	-	-	-	-
HEART ROTS (Many species)	++	+	++	++
ROOT DISEASES (Several species)	+	+	+	+
FOLIAR DISEASES				
Spruce needle rust	-	-	-	-
Spruce needle blights	-	-	-	-
Hemlock needle rust	-	-	-	-
Cedar foliar diseases	-	-	-	-
Hardwood leaf diseases	-	-	-	-
SHOOT DISEASES				
Sirococcus shoot blight	-	-	-	-
Shoot blight of yellow-cedar	-	+	-	-
DECLINES				
Yellow-cedar decline	++	++	++	+
ANIMAL DAMAGE				
Porcupines	+	-	-	+
Brown Bears	+	-	-	+

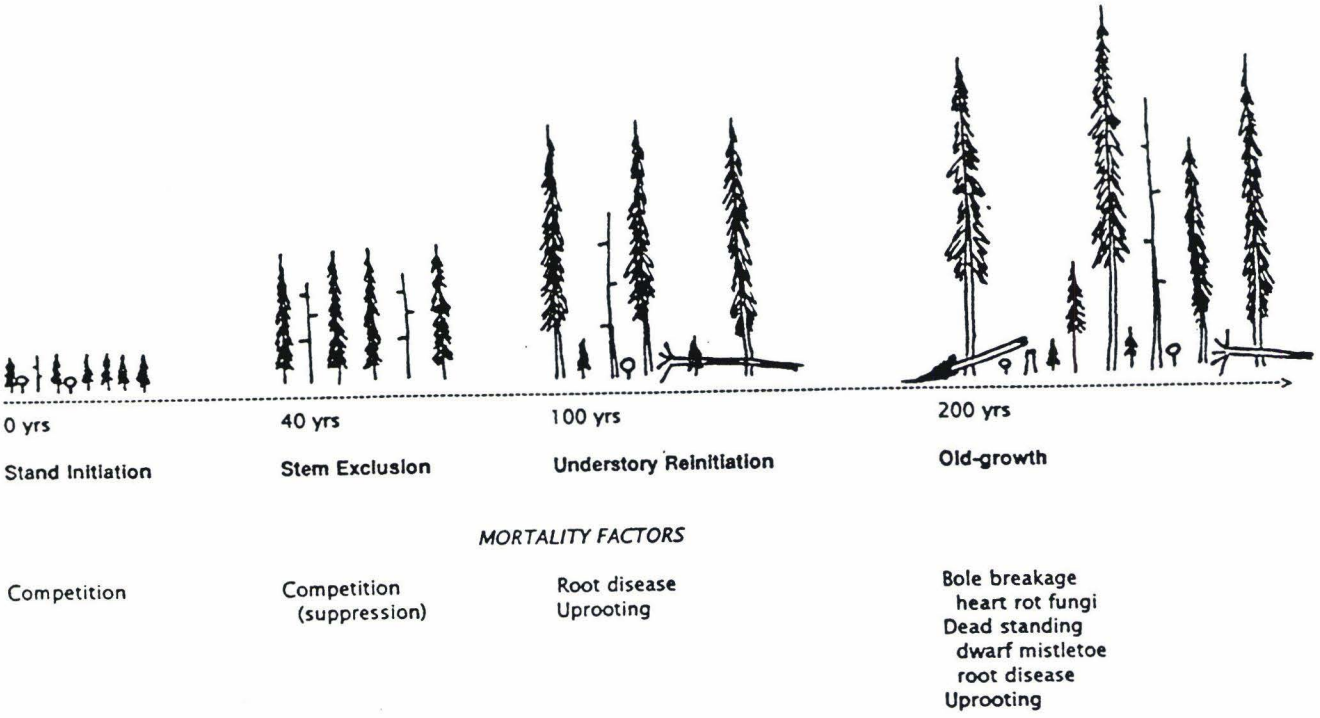


Figure 10. Role of diseases in developmental stages following catastrophic disturbance (e.g., large-scale windthrow, clearcut harvest) in the forests of coastal Alaska. Terms of stand development stages are from Oliver, C. and Larsen, B.C., 1990, Forest Stand Dynamics, McGraw-Hill, New York, 467p. Note the lack of major influence of disease in early successional stages where most mortality is through competition. Numerous diseases are present (e.g., foliar and shoot diseases) at these early successional stages, but none has a predominant effect on forest development. By contrast, diseases appear to be major mortality factors (i.e., disturbance agents) in the understory reinitiation stage. This stage can be interpreted as the transition from even-aged stands breaking up to enter the old-growth stage. Disease appears to be responsible for initiating this change by killing dominant and codominant trees. Heart rot fungi appear to be play a critical role in the maintenance of old-growth by inducing bole breakage which is one of the most common forms of canopy gap level disturbance in old coastal forests. It is conceivable that hemlock dwarf mistletoe intensifies as a stand persists in the old-growth condition for many centuries, reaching such high disease levels that vertical structure and productivity are eroded through time. Thus, the old-growth stage in coastal Alaska may be either sustained by disease in a sort of dynamic equilibrium through the canopy gap process or it may be continually altered until the next catastrophic disturbance. Research is currently evaluating the above proposed scenario.

STEM DISEASES

HEMLOCK DWARF MISTLETOE

Arceuthobium tsugense (Rosendhal) G.N. Jones

Hemlock dwarf mistletoe is an important disease of western hemlock in unmanaged, old-growth stands throughout southeast Alaska as far north as Haines. Within the range of western hemlock, dwarf mistletoe is absent from Cross Sound to the northwest along the Gulf of Alaska. The incidence of dwarf mistletoe varies in old-growth hemlock stands in southeast Alaska from stands in which almost every western hemlock tree is severely infected to other stands in which the parasite is absent (Figure 6, page 24). The dominant small-scale (canopy gap) disturbance pattern in the old forests of coastal Alaska favors the short-range dispersal mechanism of hemlock dwarf mistletoe and may explain the common occurrence of the disease here. Infection of Sitka spruce is uncommon and infection of mountain hemlock is rare. The disease is uncommon on any host above elevations of approximately 1,000 feet. Heavily infected western hemlock trees have branch proliferations (witches-brooms), bole deformities, reduced height and radial growth, less desirable wood characteristics, top-kill, and severely infected trees may die.

These symptoms are all potential problems in stands managed for wood production. Growth loss in heavily infested stands can reach 40% or more. On the other hand, witches-brooms, wood decay associated with bole infections, and scattered tree mortality can result in greater diversity of forest structure and increased animal habitat. Witches-brooms may provide hiding or nesting habitat for birds or small mammals, although this topic has not been adequately researched in Alaska. The inner bark of swellings and the seeds and shoots of the parasitic plants are nutritious and often consumed by small mammals. Heavily infected hemlock stands can begin to decline and collapse to the extent that vertical structural diversity and animal habitat are diminished, however. Stand composition is altered when mixed-species stands are heavily infected; growth of resistant species such as Sitka spruce and cedar is enhanced.

Spread of the parasite into young-growth stands that regenerate following "clear cutting" is typically by: 1) infected non-merchantable hemlock trees (residuals) which are sometimes left standing in cut-over areas, 2) infected old-growth hemlocks on the perimeters of cut-over areas, and 3) infected advanced reproduction. Residual trees may play the most important role in the initial spread to young stands. Managers using alternative harvest techniques (e.g., large residuals left standing in clearcuts, small harvest units, or partial harvests) should recognize the potential reduction in timber volume and value from hemlock dwarf mistletoe under some of these silvicultural scenarios. But substantial reductions are only associated with very high disease levels. High levels of hemlock dwarf mistletoe will only result if numerous, large, intensely-infected hemlocks are well-distributed after harvest. Mistletoe management appears to be a good tool in balancing several resource objectives. Selective harvesting techniques will be the silvicultural method for maintaining desirable levels of this disease if management intends to emphasize structural and biological diversity along with timber production.

HEMLOCK CANKER

Xenomeris abietis Barr. and other fungi

Hemlock canker, which occurred at outbreak levels during the early 1990's, was at low levels in 1996. It had been

conspicuous along unpaved roads on Prince of Wales Island, Kuiu Island (Rowan Bay road system), Chichagof Island (Corner Bay road system) and near Carroll Inlet on Revillagigedo Island. It was also observed in several unroaded areas. Infection of new trees was infrequent in 1996.

The causal agent has not been conclusively determined. Road dust and a fungus appear to be responsible for outbreaks of this disease.

Ecologically, stand composition and structure are the primary effects of hemlock canker. Tree species, other than western and mountain hemlock, are resistant and benefit from reduced competition. Wildlife habitat, particularly for deer, may be enhanced where the disease kills understory hemlock; which tends to out-compete the more desirable browse vegetation.

SPRUCE BROOM RUST

Chrysomyxa arctostaphyli Diet.

Broom rust is common throughout interior and south-central Alaska but is found in only several local areas of southeast Alaska (e.g., Halleck Harbor area of Kuiu Island and Glacier Bay). The disease is abundant only wherever any species of spruce grow near the alternate host, bearberry or kinnikinnick (*Arctostaphylus uva-ursi*) in Alaska. The fungus cannot complete its life cycle unless both host types (spruce and bearberry) are present.

Infections by the rust fungus result in dense clusters of branches (witches brooms) on white, Lutz, Sitka, and black spruce (Figure 7, page 24). The actual infection process may be favored during specific years, but the incidence of the perennial brooms changes little from year to year.

The disease may cause slowed growth on spruce, although this has not been determined by research. The dense clusters of branches and needles (brooms) are known to provide nesting and hiding habitat for some birds and small mammals.

WESTERN GALL RUST

Peridermium harknessii J.P. Moore

Infection by the gall rust fungus *P. harknessii* causes spherical galls on branches and main boles of shore pine. The disease was extremely common throughout the distribution of pine in Alaska in 1996. Infected pine tissues are swollen but not always killed by the rust fungus. Another fungus, *Nectria macrospora*, colonized and killed many of the pine branches with *P. harknessii* galls this year. The combination of the rust fungus and *N. macrospora* frequently caused top-kill. Even though very abundant, the disease does not appear to have a major ecological effect in Alaskan forests.

HEART ROTS OF CONIFERS

Heart rot decay cause enormous loss of wood volume in Alaskan forests. For example, roughly ⅓ of the old-growth timber volume in southeast Alaska is defective largely because of heart rot fungi. These extraordinary effects occur where long-lived tree species predominate such as old-growth forests in southeast Alaska. The great longevity of individual trees allows ample time for the slow-growing decay fungi to cause significant amounts of decay. Wood decay fungi play an important role in

the structure and function of coastal old-growth forests where fire and other forms of catastrophic disturbance are uncommon. By predisposing large old trees to bole breakage, these fungi serve as important disturbance factors that cause small-scale canopy gaps. All major tree species in southeast Alaska have been found killed in this manner. In south-central and interior Alaska forests, fire is the primary disturbance agent. Fires often leave scars on surviving trees, providing wounds that can be invaded by a wide array of wood decay fungi. The long-term direct and indirect interactions between fire and fungi are complex and poorly understood.

Heart rot fungi enhance wildlife habitat -- indirectly by increasing forest diversity through gap formation and more directly by creating hollows in live trees or logs for species such as bears and cavity nesting birds.

The importance of decay fungi in managed young-growth conifer stands is less certain. Wounds on live trees caused by logging activities allow for the potential of decay fungi to cause appreciable losses. Heart rot in managed stands can be manipulated to desirable levels by controlling bole wounding and top breakage during stand entries. In some instances, bole breakage is sought to occur in a specific direction (e.g., across steams for coarse wood debris input). Artificially wounding trees on the side of the bole that faces the stream can increase the likelihood of tree fall in that direction. Studies in progress are investigating how frequently fungi enter wounds of different sizes and the rate of subsequent decay in these wounded trees. Generally, larger, deeper wounds and larger diameter breaks in tops result in a faster rate of decay. Preliminary results indicate that heart rot development is much slower in southeast Alaska than areas studied in the Pacific Northwest.

In southeast Alaska, the following fungi are the most important causes of wood decay in live trees:

Sitka spruce
Fomitopsis pinicola
Phellinus pini
Phaeolus schweinitzii
Laetiporus sulphureus

Western red cedar
Poria albipellucida

Western hemlock
Fomitopsis pinicola
Laetiporus sulphureus
Phaeolus schweinitzii
Phellinus hartigii
Phellinus pini

In south-central and interior Alaska, the following fungi cause wood decay in live trees:

White and Lutz spruce
Fomitopsis pinicola
Phellinus pini
Coniophora puteana
Pholiota spp.
Phaeolus schweinitzii
Laetiporus sulphureus

Mountain hemlock
Phellinus pini
Echinodontium tinctorium
Fomitopsis pinicola

Wood decay fungi decompose branches, roots, and boles of dead trees; therefore, they play an essential role in recycling wood in forests. However, sap rot decay also routinely and quickly develops in spruce trees attacked by spruce bark beetles. Large

amounts of potentially recoverable timber volume are currently being lost annually on the Kenai Peninsula, where salvage logging has not kept pace with tree mortality from the continuing spruce beetle epidemic. Significant volume loss from sap rot and heart rot appears to begin about 4-5 years following tree death. Several species of sap rot fungi are associated with spruce beetle-caused mortality with *Fomitopsis pinicola* being the most common.

STEM DECAY OF HARDWOODS

Stem decay is the most important cause of volume loss in Alaskan hardwood species. Incidence of stem decay in paper birch and trembling aspen in south-central and interior Alaska is generally high by the time a stand has reached maturity, approximately 60 to 80 years old. These fungi will limit harvest rotation age of forests that are managed for wood production purposes. Studies are currently underway to determine volume loss by stand age class and forest type.

Ecologically, stem decay fungi alter stand structure and composition through premature bole breakage. Species composition of mixed stands may be altered so that conifers dominate some sites as hardwood trees succumb to bole breakage.

In south-central and interior Alaska, the following fungi cause stem decay in live trees:

Paper birch
Phellinus igniarius
Pholiota spp.
Poria obliqua
Pleurotus spp.

Trembling aspen
Phellinus tremulae
Pholiota spp.
Pleurotus spp.

A number of fungi cause stem decay in balsam poplar, black cottonwood, and other hardwood species in Alaska.

SHOOT DISEASES

SIROCOCCUS SHOOT BLIGHT
Sirococcus strobilinus Pruess.

Young-growth western hemlock shoots were killed in moderate levels by the blight fungus *S. strobilinus* in southeast Alaska during 1996. Sitka spruce and mountain hemlock are attacked but less frequently and less severely. Thinning may be of some assistance in reducing damage by the fungus as thinned stands have fewer infections than unthinned stands.

This disease is typically of minimal ecological consequence because infected trees are not often killed and young hemlock stands are so densely stocked. Species composition may be altered to some degree where trees other than western hemlock may be favored by the disease.

SHOOT BLIGHT OF YELLOW-CEDAR
Apostrasseria sp.

Yellow-cedar regeneration suffered substantial infection and shoot blight by the fungus *Apostrasseria* sp. in southeast Alaska in 1996 as it does every year. The disease does not affect mature cedar trees, however.

Shoot Blight of Yellow-cedar, cont.

Attack by the fungus causes terminal and lateral shoots to be killed back 10 to 20 cm on seedlings and saplings during winter or early spring. Entire seedlings up to 0.5m tall are sometimes killed. The newly discovered fungus that causes the disease, *Apostrasseria* sp., is closely related to other fungi that cause disease on plants under snow. The fungus *Herpotrichia juniperi* is often found as a secondary invader on seedlings after they die.

This shoot blight disease probably has more ecological impact, than similar diseases on other host species, because the natural regeneration of yellow-cedar is limited in many areas. By killing the leaders of yellow-cedar seedlings and diminishing their ability to compete with other vegetation, the pathogen reduces the regeneration success of yellow-cedar and thereby alters species composition.

CANKER FUNGI

Cryptosphaeria populina (Pers.) Sacc.
Cenangium singulare (Rehm.) D. & Cash
Ceratocystis fimbriata Ell. & Halst.
Cytospora chrysosperma Pers. ex Fr.
Nectria galligena

These fungi primarily cause trunk deforming cankers (Figure 8, page 24) and wood decay of many hardwood species, particularly trembling aspen, in south-central and interior Alaska. Although most are considered weak parasites, *C. singulare* can girdle and kill a tree within six years. All the canker-causing fungi were at endemic levels in 1996.

Ecologically, canker fungi alter stand structure and composition through trunk deformity and breakage. Conifer trees will benefit from reduced competition.

FOLIAR DISEASES

SPRUCE NEEDLE BLIGHTS

Lirula macrospora (Hartig) Darker
Lophodermium picea (Fuckel) Höhn.
Rhizosphaera pini (Corda) Maubl.

The fungus *Lirula macrospora* is the most important needle pathogen of Sitka spruce. In 1996 it occurred at moderate levels. It was most common on young Sitka spruce and the lower crowns of larger trees throughout coastal Alaska. *Lophodermium picea* was present at low infection levels in 1996. This disease is more typical of larger, older trees of all spruce species in Alaska. *Rhizosphaera pini* continued at endemic levels after causing damage several years ago in coastal Alaska. It had been killing the lower, inner crown of Sitka spruce in several areas around Juneau. Damage closely resembles that caused by spruce needle aphid and microscopic observation of the tiny fruiting bodies on infected needles is necessary for proper identification.

The primary impact of these needle diseases is one of appearance. They can cause severe discoloration or thinning of crowns but typically have only negligible ecological consequence. However, repeated heavy infections may slow the growth of spruce and benefit neighboring trees, thereby altering species composition to some degree.

SPRUCE NEEDLE RUST

Chrysomyxa ledicola Lagerh.
Chrysomyxa weirii Jacks.

Spruce needle rust, caused by *C. ledicola*, occurred at moderate levels in 1996 throughout southeast Alaska. The disease

was abundant on numerous poorly drained sites in many areas across southeast Alaska. The disease occurred at low levels on white and Lutz spruce in south-central and interior Alaska. An outbreak of over 2,700 acres was visible from Soldotna to Homer on the Kenai Peninsula.

The spores that infect spruce needles are produced on the alternate host, Labrador-tea (*Ledum* spp.), a plant that is common in boggy areas; thus the disease on spruce is most pronounced in these boggy (muskeg) areas. Although the disease can give spruce trees the appearance of being nearly dead, trees rarely die from this disease even in years of intense infection.

On Sitka spruce, the primary ecological consequence of the disease may be to reduced tree vigor of a species already poorly adapted to boggy sites. Repeated infection of spruce may alter forest composition by favoring other tree species.

The foliar rust fungus *C. weirii* was found sporulating on one-year old Sitka spruce needles in several areas of southeast Alaska but it has never been detected at threatening levels. Unlike most other rust fungi, no alternate host is necessary to complete its life cycle. Little ecological or economic impact results from this disease.

HEMLOCK NEEDLE RUST

Pucciniastrum vaccinii (Rab.) Joerst.

Hemlock needle rust was found at the highest level since the 1970's throughout southeast Alaska during 1996. The disease was most damaging near Yakutat where it caused defoliation of western hemlock, especially on trees growing adjacent to harvested sites. Elsewhere, infected needles were found, but hemlock trees were not heavily defoliated. The alternate hosts for the rust fungus include several *Vacinium* spp. Infection levels usually return to endemic levels in a year or so and the disease is not expected to influence major ecological change.

ROOT DISEASES

Several root diseases cause volume loss and mortality of conifers in Alaskan forests. Root rot fungi cause extensive decay of root systems and the lower trunk of trees. As a consequence, tree growth and volume are reduced due to decreased water and nutrient uptake. Mortality of individual or clumps of trees occurs within enlarging infection centers. Seedlings of susceptible tree species planted within the centers are particularly susceptible to mortality. Older trees may be infected but remain living for several decades with reduced tree growth and wood volume.

Ecologically, root diseases are considered natural, perhaps essential, parts of the forest altering stand structure, composition, and increasing plant community diversity. Resistant tree species, including all hardwood trees, benefit from reduced competition within infection centers. Wildlife habitat is enhanced by small-scale mortality centers, increased volume of large woody downed material, and increased hardwood browse vegetation.

STAND OPENING DISEASE

Inonotus tomentosus (Fr.:Fr.) Teng.

This root disease occurs in white and Lutz spruce stands in south-central and interior Alaska from Homer to Fairbanks. In 1996 it occurred at endemic levels.

Spruce trees of all ages are susceptible to infection; saplings as young as 15 years may succumb to the disease. Studies are currently underway to determine the size of mortality centers, as well as stand and site factors that influence the amount of disease in an area.

The stand opening disease may have more ecological impact than similar root rots on other hosts, particularly in managed stands where natural regeneration of white and Lutz spruce is limited and adequate restocking requires planting. Hardwood trees are resistant and may colonize infection centers. Wildlife habitat, particularly for moose, may be enhanced by increased hardwood browse vegetation.

ANNOSUS ROOT AND BUTT ROT

Heterobasidion annosum (Fr.) Bref.

Annosus commonly causes butt-rot in old-growth western hemlock and Sitka spruce forests in southeast Alaska. It is not known to occur in south-central or interior Alaska. This disease was at endemic levels in 1996.

Spores of the fungus are known to readily infect fresh stump surfaces, such as those found in clearcuts or young pre-commercially thinned stands. However, studies in managed stands have indicated limited stump inoculation and survival of the fungus. Thus, this disease poses minimal threat to young managed stands.
Reasons for the limited stump inoculation in southeast Alaska as compared to other regions of the Pacific Northwest are not completely understood but may be related to climate. High rainfall and low temperatures, common in Alaska's coastal forests, apparently hinder spore development. Frequent rains waterlog stump surfaces and readily wash spores from surfaces. Cool temperatures reduce water evaporation which helps to maintain high moisture content in stumps, further hindering spore development.

LAMINATED ROOT ROT

Phellinus weirii (Murr.) Gilb.

Laminated root rot is an important disease of western red cedar in southeast Alaska, causing nearly half of the decay in old-growth trees. No other conifer species in Alaska is known to be infected by the fungus. Thus, it is generally accepted that only the red cedar form of the fungus occurs in Alaska. This disease was at endemic levels in 1996.

ARMILLARIA ROOT DISEASE

Armillaria spp.

Several species of *Armillaria* occur in the coastal forests of southeast Alaska, but in general, the species are less-aggressive saprophytic slash decomposers that only kill trees when they are under some form of stress. Studies in young managed stands indicated that *Armillaria* spp. will colonize fresh stumps, but will not successfully attack adjacent trees. In 1996, *Armillaria* spp. occurred at endemic levels. In south-central and interior Alaska, there is a poor understanding of the species that are present and their respective aggressiveness.

FOLIAGE DISEASES OF CEDARS

Gymnosporangium nootkatense Arth.
Didymascella thujina (Durand) Maire

Two fungi that infect the foliage of cedar, *G. nootkatense* on yellow-cedar and *D. thujina* on western red cedar, occurred at endemic levels this year. *D. thujina* was the more damaging of the two and was common wherever its host was found. Neither fungus resulted in severely defoliated nor death of cedar trees. Neither disease has major ecological effects.

YELLOW-CEDAR DECLINE

Decline and mortality of yellow-cedar persists as one of the most spectacular forest problems in Alaska. About 475,000 acres of decline have been mapped during aerial detection surveys. (The difference between 1995's total of 595,000 and 1996 total is due to better mapping and GIS abilities, the areas have not changed.) Concentrated mortality occurs in a wide band from western Chichagof and Baranof Islands to the Ketchikan Area. Of the three administrative areas of the Tongass National Forest, the Stikine Area has the greatest concentration of cedar decline at more than 200,000 acres.

All research suggests that no contagious organism is the primary cause for this extensive mortality. Some site factor, probably associated with the poorly- drained anaerobic soils, appears to be responsible for initiating and continuing cedar decline. Two hypotheses have been proposed to explain the primary cause of cedar decline -- death could result from (1) toxins produced by decomposition in the wet, organic soils or (2) freezing damage to shallow fine roots associated with climatic warming and reduced insulating snowpacks in the last century. These hypotheses are developed in some detail (Hennon and Shaw 1994). Interestingly, considerable concentrations of newly-killed trees were evident in declining forests during 1996, perhaps a response to the unusually prolonged cold temperatures with little snowpack that persisted during the 1995/6 winter. Whatever the primary cause of this mysterious decline, it is probably a naturally-occurring phenomenon. Research suggests that the total acreage of yellow-cedar decline has been increasing very gradually; the slow increase in area has been a result of the expansion of existing decline (<3 feet/year) into adjacent stands. Most stands contain trees that died up to 100 years ago (snags still standing), as well as recently killed cedars, dying cedars (with yellow, red, or thinning crowns), healthy cedars, and other tree species. Numerous very recently-killed trees and dying trees with full, but off-color crowns were present in many stands during 1996 (Figure 9, page 24).

Ground surveys indicate that 65% of the basal area of yellow-cedar is dead on this acreage. Other tree species are affected in different ways: on some sites they produce increased growth, presumably due to less competition, and on other sites they experience slowed growth and mortality because of site deterioration (poor drainage). Species change to western hemlock and mountain hemlock appears to be occurring in some stands where decline has occurred for up to a century.

Little is known about wildlife use and dependency of yellow-cedar forests, and whether these forests are experiencing excessive mortality or not. The primary ecological effect of yellow-cedar decline is to alter stand structure (i.e., addition of numerous snags), composition (i.e., yellow-cedar diminishing and other tree species becoming more numerous), and the eventual succession to other conifer species. The creation of numerous snags is not particularly beneficial to cavity-using animals because yellow-cedar wood is less susceptible and slow to decay. Region-wide, this excessive mortality of yellow-cedar may lead to diminishing populations (but not extinction) of yellow-cedar, particularly when the poor regeneration of the species is considered.

The large acreage of dead yellow-cedar and the high value of its wood suggest opportunities for salvage. Cooperative studies with the Wrangell Ranger District, the Forest Products Lab. in Madison, Wisconsin, and State and Private Forestry are investigating the mill-recovery and wood properties of snags of yellow-cedar that have been dead for varying lengths of time.

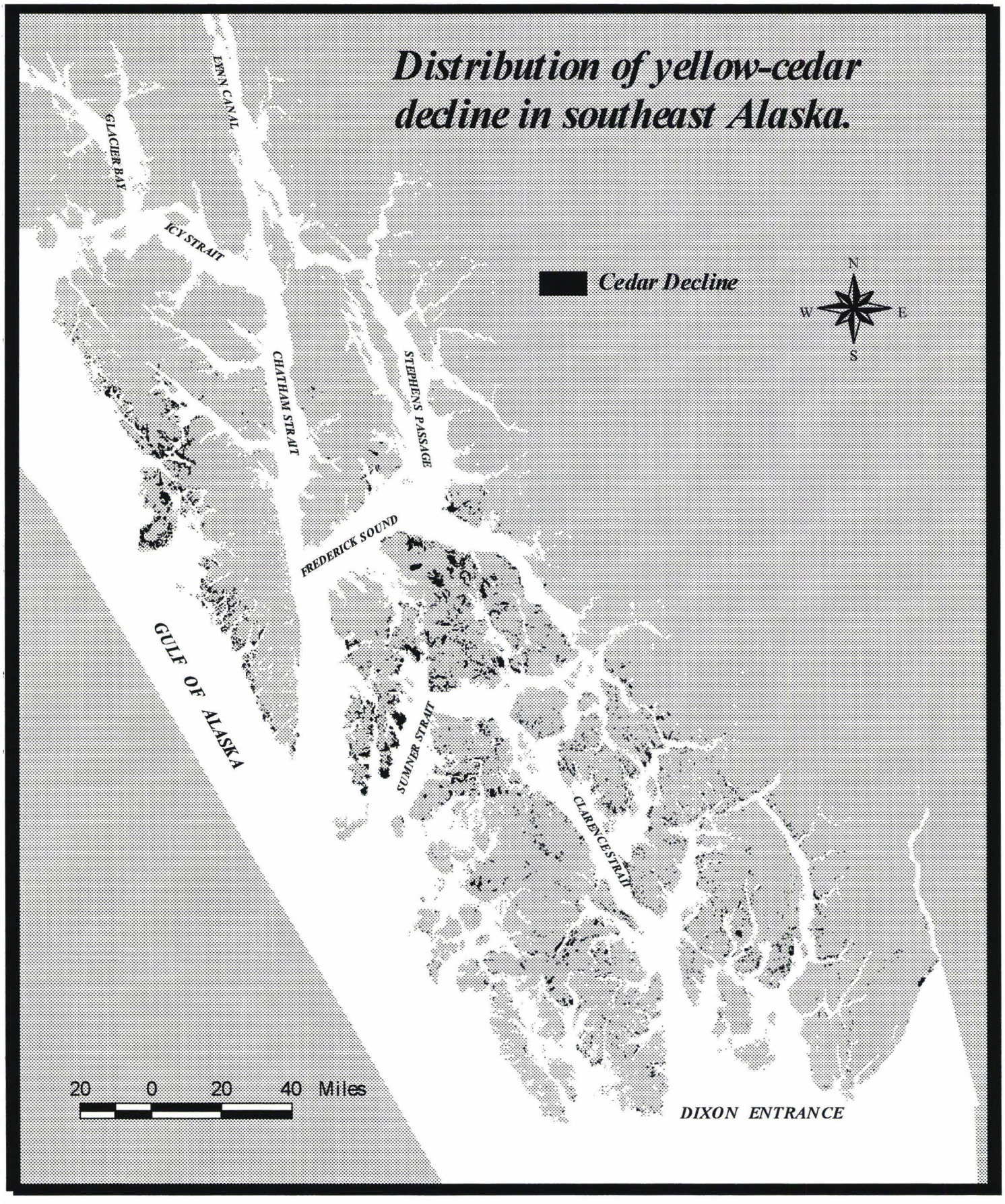

Distribution of yellow-cedar decline in southeast Alaska.
Cedar Decline
N
W
E
S
GLACIER BAY
LYNN CANAL
ICY STRAIT
CHATHAM STRAIT
STEPHENS PASSAGE
FREDERICK SOUND
GULF OF ALASKA
SUMNER STRAIT
CLARENCE STRAIT
DIXON ENTRANCE
20 0 20 40 Miles

Figure 11.

Table 3. Acreage affected by yellow-cedar decline in southeast Alaska in 1996.

	Acres
NATIONAL FOREST LAND	452,333
Chugach Area	
Cordova Ranger District	340
Chatham Area	117,286
Juneau Ranger District	902
Hoonah Ranger District	973
Sitka Ranger District	
Chichagof I	34,478
Baranof I	49,637
Kruzof I	25,809
Total	115,411
Admiralty Island Nat'l Mon. Wilderness	5,487
Stikine Area	203,674
Petersburg Ranger District	
Kupreanof I	82,792
Kuiu I	64,786
Mitkof I	5,730
Woewodski I	2,057
Mainland	7,566
Total	162,931
Wrangell Ranger District	
Etolin I	17,304
Wrangell I	9,368
Zarembo I	3,334
Woronofski I	368
Mainland	10,369
Total	40,743
Ketchikan Area	131,033
Thorne Bay Ranger District	
Prince of Wales I	29,552
Kosciusko I	12,461
Heceta I	868
Total	42,881
Ketchikan Area (continued)	
Craig Ranger District	
Prince of Wales I	29,547
Dall I. and Long I	1,026
Total	30,573
Ketchikan Ranger District	
Revillagigedo I	16,969
Gravina I	1,225
Mainland	13,396
Total	31,590
Misty Fjords Nat'l Mon. Wilderness	
Revillagigedo I	8,831
Mainland	17,158
Total	25,989
NATIVE LAND	15,928
Prince of Wales I	7,712
Dall and Long I	611
Kupreanof I	3,445
Baranof and Chichagof I	595
Ketchikan area	2,714
Annette I	851
STATE AND PRIVATE LAND	6,603
Baranof I	993
Mitkof I	645
Kupreanof I	345
Prince of Wales I	1,773
Wrangell area	213
Admiralty I	9
Revillagigedo	725
Gravina I	766
Kosciusko I	526
Other mainland	608
TOTAL LAND AFFECTED	**474,864**

HEMLOCK FLUTING

Deeply incised grooves and ridges extending vertically along boles of western hemlock characterize hemlock fluting. Bole fluting is common on western hemlock throughout southeast Alaska. This condition reduces the value of hemlock logs because they yield less sawlog volume and bark is contained in some of the wood. The cause of fluting is not completely known, but associated factors include: increased wind-firmness of fluted trees, fluted trees commonly occur on sites with shallow soils, and growth release triggers fluting. The asymmetrical radial growth appears to be caused by unequal distribution of carbohydrates due to the presence of dead branches. Researchers have documented the development of fluting in young hemlock stands that regenerated following clearcut harvesting or other disturbance. After several centuries, fluting is no longer outwardly visible in some trees because branch scars have healed over and fluting patterns have been engulfed within the stem.

Bole fluting has important economic impact, but may have little ecological consequence beyond adding to windfirmness. The deep folds on fluted stems of western hemlock may be important habitat for some arthropods and the birds that feed upon them.

WATER DAMAGE

More than 4,500 acres of flood damaged spruce and hardwoods were observed in 1996 in south-central and interior Alaska. The largest impacted area, over 2,000 acres, was noted in the Matanuska Valley, near the mouth of the Matanuska River.

Flood damage to conifer stands occurred in scattered locations in southeast Alaska, totaling approximately 1,000 acres. Some small areas of high water damage to conifers were the result of beaver dams.

WINTER INJURY

Winter injury was widespread throughout southeast Alaska. The 1995-6 winter was unusually cold and dry with long periods of little to no snowpack at low elevations. Many tree species sustained injury and exhibited thin crowns, a dead side of the crown, dead branches, or outright mortality the following spring. Smaller trees and those in exposed locations suffered the greatest mortality. Both forest trees and evergreen ornamental trees were damaged or killed. The foliage of many trees was killed but buds were not injured and produced a flush of growth in spring. Tree species sometimes suspected of being adapted to cold climates, e.g., mountain hemlock, were damaged or killed. Shore pine and Sitka spruce in exposed areas near Gustavus suffered the most extensive mortality.

The actual physiological process involved in winter injury is not known. Winter injury may be caused by freezing injury to cells because of chronic exposure to frigid temperatures, chronic desiccation because roots and soil are frozen but crowns are transpiring moisture, or acute freezing injury and cellular damage when the temperature rapidly changes from moderate to frigid and tissues have lost some degree of cold-hardiness. The latter two scenarios are supported by the commonly observed damage to the exposed portion of tree crowns.

STATUS OF ANIMAL DAMAGE

PORCUPINE

Erethizon dorsatum

Porcupines cause severe damage to Sitka spruce and western hemlock in numerous local areas of southeast Alaska. An extensive survey documents the level of porcupine damage in young-growth stands. Feeding injuries to trees are confined to the known distribution of porcupine; thus, trees are not damaged where the porcupine is absent such as Prince of Wales, Kuiu, Baranof, Chichagof, and Admiralty Islands. Damage is especially serious on Mitkof Island in southeast Alaska. Other damage has been noted at Thomas Bay, Cleveland Peninsula, Bradfield Canal, Anita Bay and other areas of Etolin Island, Douglas Island, and the Juneau area. Shore pine near Haines has been damaged the last few years. Porcupines also damage trees throughout interior Alaska. Bark beetles, including *Ips* spp., have been found infesting the damaged trees.

In southeast Alaska, the feeding behavior of porcupines changes as forests develop and trees become larger and older. Porcupines climb smaller trees and kill or cause topkill by removing bark along the entire bole, or the bole near the top of the tree. As trees become larger, around 40-50 years old, porcupines climb fewer trees and most of the damage is in the form of basal wounding. Most of these larger trees are not killed, but the large basal scars allow fungi to enter the bole and begin to cause wood decay.

The primary ecological consequences of porcupine feeding are: (1) to provide greater diversity of structure and vegetation in young, even-aged conifer stands through mortality and (2) to provide greater levels of heart rot decay by wounding older trees. This latter effect can alter mortality patterns in old forests as trees may often die through bole breakage.

BROWN BEAR

Ursus arctos

Yellow-cedar trees were wounded in the spring by brown bears on Baranof and Chichagof Islands. Brown bears rip the bark away from the lower boles of these trees, apparently to lick the sweet cambium. Other tree species in southeast Alaska are unaffected. White spruce and occasionally aspen were injured in south-central Alaska on the Kenai Peninsula. Trees with old scars have associated columns of wood decay that will limit the value of their butt logs. Ecologically, this interaction of bears and trees may benefit the bears directly by providing nourishment. In addition, stand structure may be altered by greater heart rot levels due to bole wounding.

MOOSE

Alces alces

At many locations across south-central and interior Alaska, moose cause severe damage to hardwood species by repeatedly browsing stems. In the winter, moose congregate in areas containing young hardwoods, often consuming the new growth on the same trees year after year. Snow cover typically protects stems less than 20 inches tall, while stems greater than 12 feet tall are generally out of reach and escape from damage. Heavy repeated browsing results in stunted malformed stems, branch wounds, and mortality. Wood decay fungi penetrate branch wounds resulting in a high incidence of stain and decay in browsed stems.

Ecologically, the primary impacts of moose browse are altered stand structure and composition. Trees that escape browse, such as spruce, benefit from reduced competition.

INTEGRATED PEST MANAGEMENT ACTIVITIES

Integrated pest management (IPM) has been described as a "systems approach to alter pest damage to acceptable levels through a variety of techniques, including predators and parasites, genetically resistant hosts, natural environmental modifications, and when necessary and appropriate, chemical pesticides." Current IPM activities in Region 10 include:

(1) Participation in a cooperative effort with the Alaska Cooperative Extension (ACE) to provide pest management information to Alaska residents. The program, which includes education, research and survey activities, also provides integrated pest management information concerning urban forestry as well as garden and greenhouse pests. The program is educational in nature and provides the public with a means to learn about pest management in an informal and accessible manner. IPM Technicians were located in Anchorage, Palmer, Soldotna, Fairbanks, Delta Junction, Juneau, and Ketchikan. They also served surrounding communities within their districts. The Anchorage site had a full time and a half time Technician; the remaining locations had one IPM Technician for the season. The total recorded client contacts reached well over 5,000 which was more than 50% of all contacts made by the Cooperative Extension Service. The 1996 Technicians conducted more than 35 workshops and over 50 media contacts. This successful outreach results largely from the Technician's enthusiastic and professional approach. As more Alaskans become informed of the availability and services of the IPM Technician Program, the Technicians, as part of the statewide ACE-IPM program, will continue to provide the most current and accessible pest identification and management information available.

In an effort to expand the outreach program, ACE and Forest Health Protection initiated the Alaska Forestry IPM Technician regional position in 1995. The Forestry IPM position was a full time position and allowed us to meet the needs of Alaskans with more specific forest pest and woodlot management issues and concerns. The Forestry Technician activities included: answering 1,400 phone calls concerning forest health issues; 634 site visits; 34 media contacts; 6 radio interviews; and 6 television appearances. We are looking closely at increasing our support for this excellent program in 1997.

(2) A preliminary test of a ground application of a water soluble formulation of MCH was undertaken in late spring of 1996. MCH is the naturally occurring antiaggregating pheromone of the spruce beetle and functions as a "repellent". Results of the test were less than satisfactory in preventing spruce beetle attacks on standing trees. Future testing of this product will be undertaken in the early spring of 1997 with a refinement of dosage rates and timing of application. A sprayable water soluble formulation has great potential for protecting high value ornamental spruce in urban areas as well as valuable campground trees.

There are also studies underway to develop and validate a plume model to determine the horizontal, vertical, and crosswind movement of MCH in a stand atmosphere. The development of this model will allow us to place specific amounts of pheromones in a forest environment based on specific stand conditions (open vs.

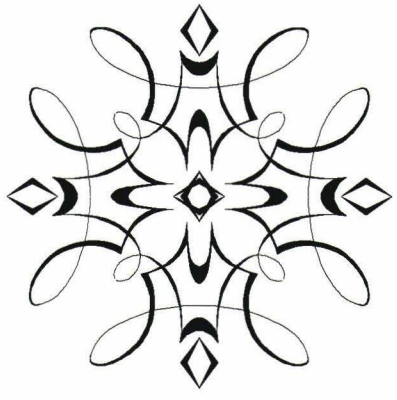
closed canopies). Likewise, studies were completed to determine the optimal amounts of natural MCH needed to repel further beetle attacks. The minimum atmospheric concentration of MCH that repels attacking spruce beetles can now be computed for stands of Lutz spruce. This minimum atmospheric concentration of MCH will be used to fine-tune the plume model next summer (1997).

(3) An Alaska Region Forest Health Protection Special Report has recently been completed (see Bibliography, Newton, M.). This report summarizes 9 years of research relating to the principal technical obstacles to artificial regeneration in south-central and interior Alaska. The key elements of this report include: 1) determination of severity of plant competition and consequences of not "weeding" in the first 5 years of spruce plantations, 2) comparisons of methods of controlling competition, and 3) evaluation of environmental impacts of the various methods of vegetation control.

(4) Two thinning studies aimed at reducing spruce beetle caused tree mortality have been established on the Kenai Peninsula. Objectives of these studies are to determine efficacy of thinning from below, pruning, and fertilization in reducing spruce beetle caused tree mortality. Changes in understory vegetation as a result of treatments (e.g logging and fertilization) and those which occur in untreated stands is also being monitored. Preliminary results have indicated a significant reduction in beetle-caused tree mortality in thinned vs. unthinned spruce stands.

(5) During 1992 aerial surveys of interior Alaska with Dr. Malcolm Furniss of the Department of Entomology, University of Idaho, Moscow, a scolytid, *Trypophloeus striatulus*, was found to be one of the most important willow infesting insects. This is so because of its involvement in killing stems and because of its wide distribution. Its biology and population dynamics has not been previously studied. A two year study was initiated in 1996 to determine the beetle's biology, host species, and factors associated with susceptibility of willows to infestation, including browsing damage, willow senescence, and plant-pathogenic fungi. Results of Dr. Furniss' 1996 field season documented five new hosts, of which, feltleaf willow, *Salix alaxensis*, being infested most frequently, as well as being most heavily browsed by moose. Infested stems die slowly, being infested by several beetle generations. Factors in common with presence of the beetle are either severe browsing damage by moose or plant senescence, and infection by a pathogenic fungus, *Cytospora* sp. The mode of transmission of *Cytospora* sp. remains unknown.

Dr. Furniss' study will continue in 1997 with the objectives of: (1) confirmation of the beetle's seasonal and life history, (2) fungi, including *Cytospora* sp., will be inoculated in feltleaf willow to seek to duplicate the wound response resulting from attack by the beetle; and (3) results of this study will be communicated to resource managers in the various agencies involved with moose and willow.



SUBMITTING INSECTS AND DISEASES FOR IDENTIFICATION

The following procedures for the collection and shipment of specimens should be used for submitting samples to specialists:

I. Specimen collection:

1. Adequate material should be collected
2. Adequate information should be noted, including the following:
    a. Location of collection
    b. When collected
    c. Who collected the specimen
    d. Host description (species, age, condition, # of affected plants)
    e. Description of area (e.g., old or young forest, bog, urban);
    f. Unusual conditions (e.g., frost, poor soil drainage, misapplication of fertilizers or pesticides?).
3. Personal opinion of the cause of the problem is very helpful.

II. Shipment of specimens:

1. General: Pack specimens in such a manner to protect against breakage.
2. Insects: If sent through the mail, pack so that they withstand rough treatment.
    a. Larvae and other soft-bodied insects should be shipped in small screw-top vials or bottles containing at least 70% isopropyl (rubbing) alcohol. Make certain the bottles are sealed well. Include in each vial adequate information, or a code, relating the sample to the written description and information. Labels inserted in the vial should be written on with pencil or India ink. Do not use a ballpoint pen, as the ink is not permanent.
    b. Pupae and hard-bodied insects may be shipped either in alcohol or in small boxes. Specimens should be placed between layers of tissue paper in the shipping boxes. Pack carefully and make certain that there is very little movement of material within the box. Do not pack insects in cotton.
3. Needle or foliage diseases: Do not ship in plastic bags. Sprinkle lightly with water before wrapping in newspaper. Pack carefully and make sure that there is very little movement of material within the box. Include the above collection information. For spruce and other conifers, include a description of whether current year's-needles, last-year's needles, or old-needles are attacked.
4. Mushrooms and conks (bracket fungi): Do not ship in plastic bags. Either pack and ship immediately, or first air dry and then pack. To pack, wrap specimens in dry newspaper and pack into a shipping box with more newspaper. If on wood, include some of the decayed wood. Be sure to include all collection information.

III. Shipping:

1. Ship as quickly as possible, especially if specimens are fresh and not air-dried. If samples cannot be shipped rapidly, then store in a refrigerator.
2. Include address inside shipping box.
3. Mark on outside: "Fragile: Insect-disease specimens enclosed. For scientific purposes only. No commercial value."

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FOREST INSECT AND DISEASE BIOLOGICAL EVALUATIONS, TECHNICAL REPORTS, AND MISCELLANEOUS PUBLICATIONS

Borden, J.H.; Gries, G.; Werner, R.A.; Holsten, E.H.; Wieser, H.; Dixon, E.A.; Cerezke. 1996. Regionally-Specific Bioactivity of Two New Pheromones for *Dendroctonus rufipennis* (Kirby) (Col., Scolytidae). J. Appl. Ent. 120: 321-326.

Hennon, P.E.; Shaw, C.G. III; Hansen, E.M. 1997. Reproduction and forest decline of *Chamaecyparis nootkatensis* in southeast Alaska. Pp. Xx-xx. In: Laderman, A., ed. Coastally restricted wetlands. Oxford Press. In Press.

Hennon, P.E. 1997. *Tsuga heterophylla*. In: eds., Schutt, Schuck, Aas, Lang, Enzyklopadie der Holzgewachse. Landsberg, Germany: Ecomed Verlag.

Holsten, E.H. 1996. Effects of a Spruce Beetle Outbreak and Fire on Lutz Spruce Stands in Alaska. In Proceedings: North American Forest Insect Work Conference, Texas Forest Service Publ. 160. Pg. 139.

Holsten, E.H. 1996. *Ips tridens*; A Pest of Managed Stands?? USDA Forest Service Alaska Region FHM Biological Evaluation R10-TP-64. 8 pp.

Holsten, E.H.; Hennon, P.; Wittwer, D.; K. Matthews. 1996. Forest Insect and Disease Conditions in Alaska--1995. USDA Forest Service Alaska Region FHM Gen. Tech. Rep. R10-TP-61. 40 pp.

Kuletz, K.; Holsten, E.; K.L. Oakley. 1997. A New Threat to Marbled Murrelets in Alaska: Spruce Beetle. Poster presentation & Abstract presented at: Pacific Seabird Conference, 7-9 January 1997, Portland, OR.

McDonald, Kent; Hennon, P.E.; Stevens, John; Greene, David. 1997. Mechanical properties of salvaged yellow-cedar in southeast Alaska. Madison, WI: U.S. Department of Agriculture, Forest Service, Forest Products Laboratory. Research Note. In Press.

Newton, M.; E.C. Cole. 1996. Reforestation and Vegetation in Central Alaska. USDA Forest Service, Alaska Region Special Report R10-TP-65. 80 pp.

Reynolds, K.M.; E.H. Holsten. 1996. SBExpert (Version 2.0) : A Knowledge-Based Decision-Support System for Spruce Beetle Management. USDA For. Serv., Alaska Region (Draft Users Manual & Software).

Reynolds, K.M.; E.H. Holsten. 1996. Classification of Spruce Beetle Hazard in Lutz and Sitka Spruce Stands on the Kenai Peninsula, Alaska. For. Ecology and Management. 84:251-262.

Schultz, Mark. 1996. Dall Island Sitka Spruce Mortality Survey - 1996. USDA Forest Service Technical Report R10-TP-63. 14pp.

Werner, R.A. 1996. Fire/Forest/Insect Interactions. In Proceedings: North American Forest Insect Work Conference, Texas Forest Service Publ. 160. Pg. 136.

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INFORMATION AVAILABLE FROM STATEWIDE AERIAL SURVEYS

Each year, forest damage surveys are conducted over approximately 25-30 million acres. This "annual survey" is a cooperative effort between U.S. Forest Service, State and Private Forestry, Forest Health Protection (USFS/FHP) and State of Alaska, Department of Natural Resources, Division of Forestry (AK/DOF) entomologists to assess general forest conditions on Alaska's 129 million acres of forested area. About 25% of Alaska's forested area is covered each summer using fixed-wing aircraft and trained observers to prepare a set of sketchmaps depicting the extent ("polygons") of various types of forest damage including recent bark beetle mortality, various hardwood and conifer defoliation, and abiotic damage such as yellow-cedar decline, as examples. A number of other damage types are noted including flooding, wind damage, and landslide areas during the survey. The extent of many significant forest tree diseases, such as stem and root decays, are not estimated from aerial surveys since this damage is not visible from aerial surveys as compared to the pronounced "red topped" crowns of spruce beetle-killed trees.

In this way, forest damage information is sketched on 1:250,000 scale USGS quadrangle maps which is a fairly small scale since one inch would equal approximately 8 miles distance on the ground. From time to time, other scale maps are used from the air to provide more detailed assessments (1:63,360 or 1 inch = 1 mile) when specialized surveys are requested from other agencies or private landowners. Due to the short Alaska summers, long distances required, high airplane rental costs, and the short time frame when the common pest damage signs and tree symptoms are most evident (usually only during July and August), sketch mappers must strike a balance to efficiently cover the highest priority areas with available personnel and funding. Thus, the entire state of Alaska is not aerially surveyed each year. Most areas not currently exhibiting insect or disease damage are monitored approximately every 3-4 years.

Prior to the annual statewide forest conditions survey, letters are sent to various state and federal agencies and other landowner "partners" for survey nominations. The federal and state entomologists decide which areas are highest priority from the nominations in addition to selecting areas where several years data are collected to establish trends from the year-to-year mapping efforts. In this way, general trend information can be prepared for the most significant pests and damage encountered on the surveys and an Annual Conditions Report prepared each year. In addition, hard copy sketchmap information is available for photocopying directly after the survey is completed each summer. Also, the sketchmap information is later digitized and put into a computerized Geographic Information System (GIS) for more permanent storage and retrieval by a number of users.

The maps in this Appendix are just a small sample of the types of products that can be prepared from the statewide surveys and GIS databases that are available. Due to the cost of mass-producing hard copy materials from GIS data, a number of other map products are not included here. In addition to these maps, which show the general extent of forest insect damage from the 1996 statewide aerial surveys, other types of map and digital data can be made available in various formats depending on the skill of the user:

Maps Included With "Forest Insect And Disease Conditions In Alaska -- 1996:

- Major Forest Pests 1996 - Aerial Detection Survey (spruce beetle, spruce budworm, larch sawfly) -- obtained from AK/DOF
- Kenai Peninsula spruce beetle survey **(1989-1996 cumulative)** -- produced by ADF&G from AK/DOF GIS database
- Copper River Basin spruce beetle survey **(1989-1996 cumulative)** -- produced by Resource Data Inc/USGS Biological Resources Division from AK/DOF database
- Southeast Alaska aerial survey damage - **1996** -- produced by USFS/FHP/Juneau

Map and GIS Products Available By Request:

- Individual GIS "quadrangle" maps for 1996 surveys on 11" x 17" format (request individual USGS quad map(s))

- Digital file information in "quad" format showing individual pest damage, major waterways and USGS place names (appropriate data disk must be provided by user)

- Digital data file of 1996 forest damage coverage in ArcInfo (ESRI, Inc.) format -- requires a specific written request to AK/DOF (nominal fee may be required)

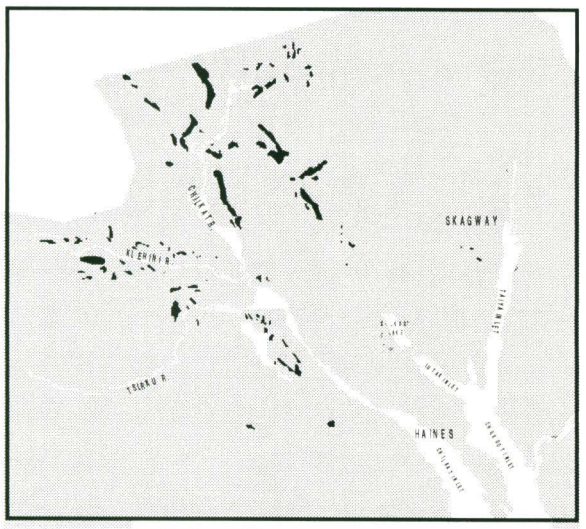
- Cumulative forest damage or specific-purpose damage maps prepared from AK/DOF's GIS database (specific request required; fee may be assessed depending on specific project(s)

- Submit requests to Attn: Roger Burnside, State of Alaska, Department of Natural Resources, Division of Forestry, 3601 "C" Street, Suite 1034, Anchorage, AK 99503-5936;
  phone: (907) 269-8460; fax: 561-6659; or E-mail: roger_burnside@dnr.state.ak.us

  or

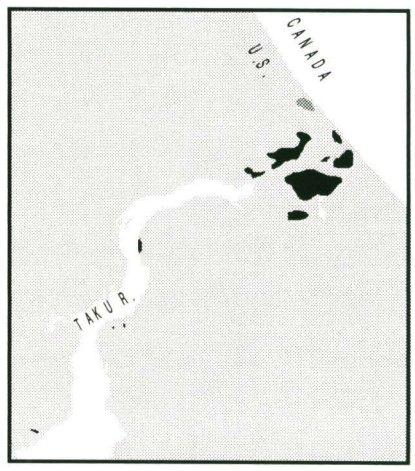
- Kathy Matthews, USDA Forest Service, State and Private Forestry, Forest Health Protection, 3301 "C" Street, Suite 522, Anchorage, AK 99503-3956; phone: (907) 271-2574; fax: 271-2897; E-mail: spf@pobox.alaska.net (Note: this E-mail address is not permanent and may change without notice.)

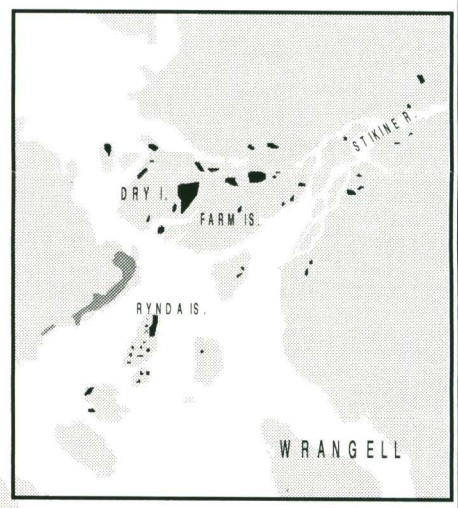
Southeast Alaska
1996 Aerial Detection Survey

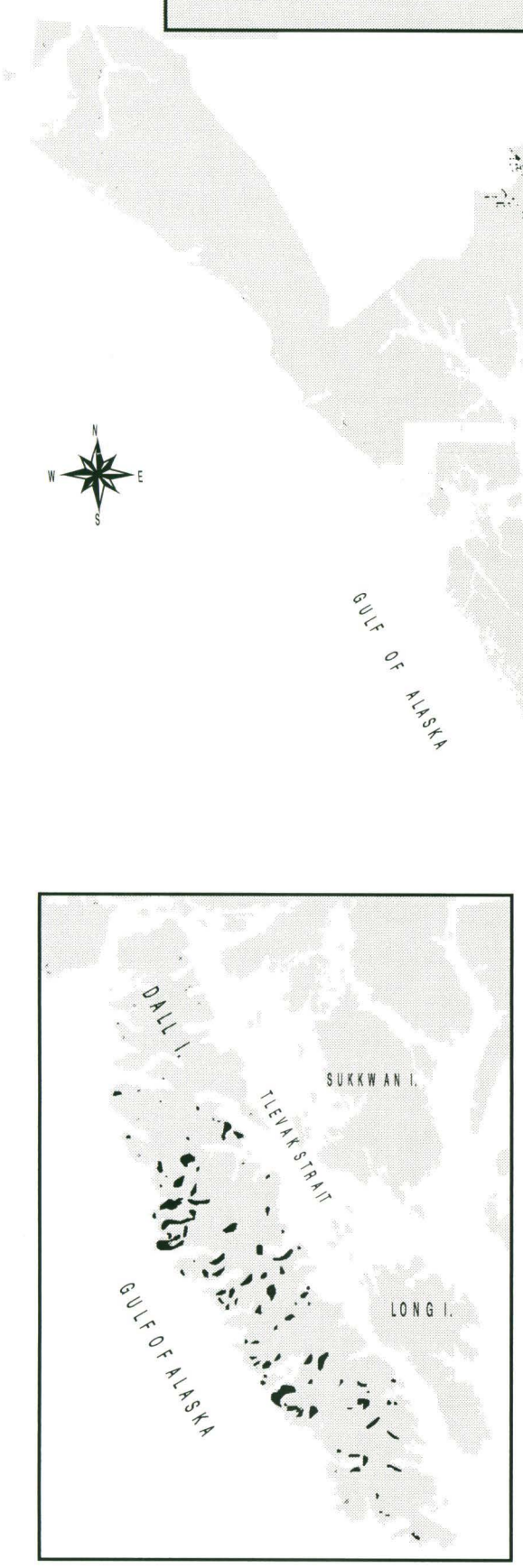


Spruce Beetle

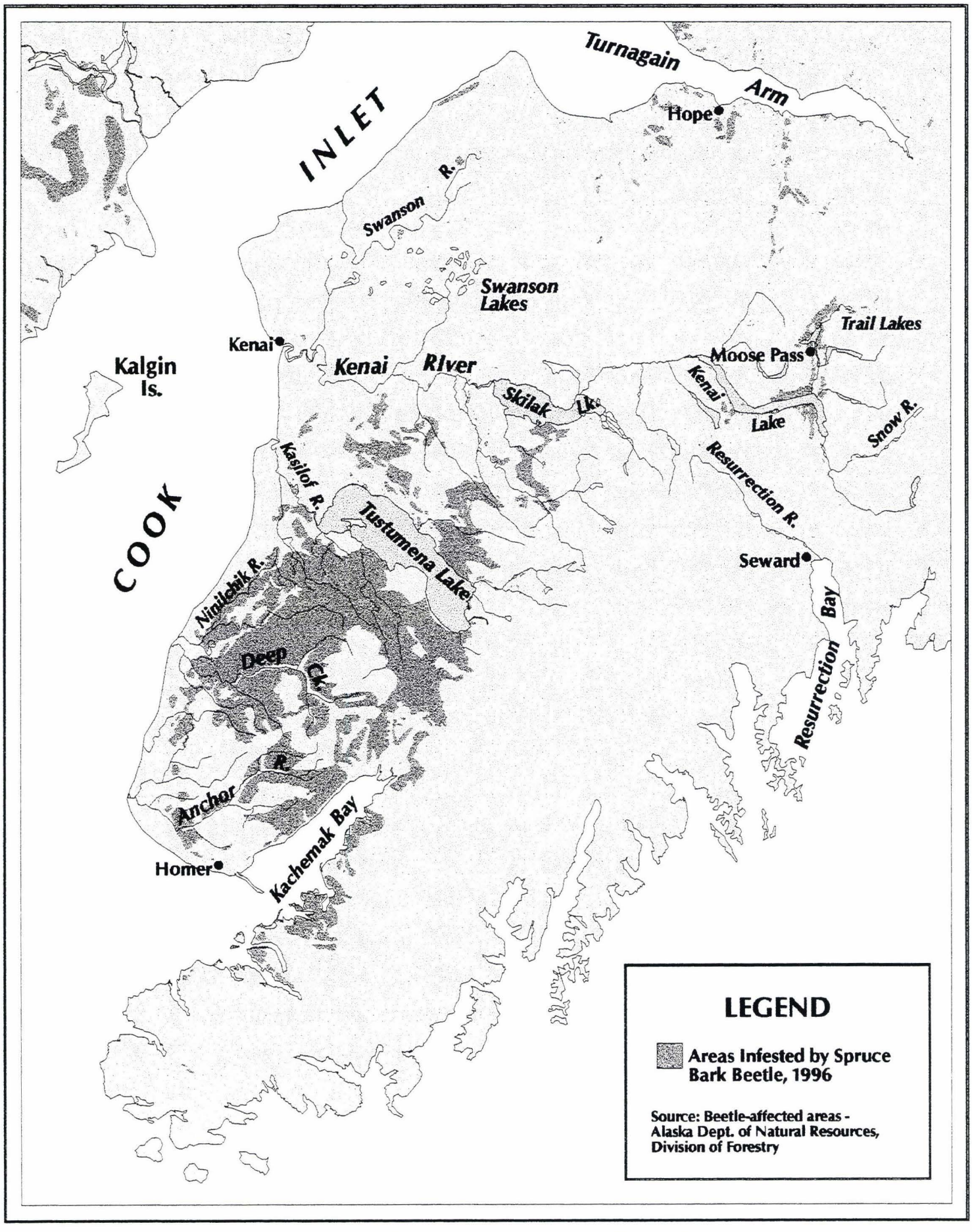
Other Insect & Disease Agents



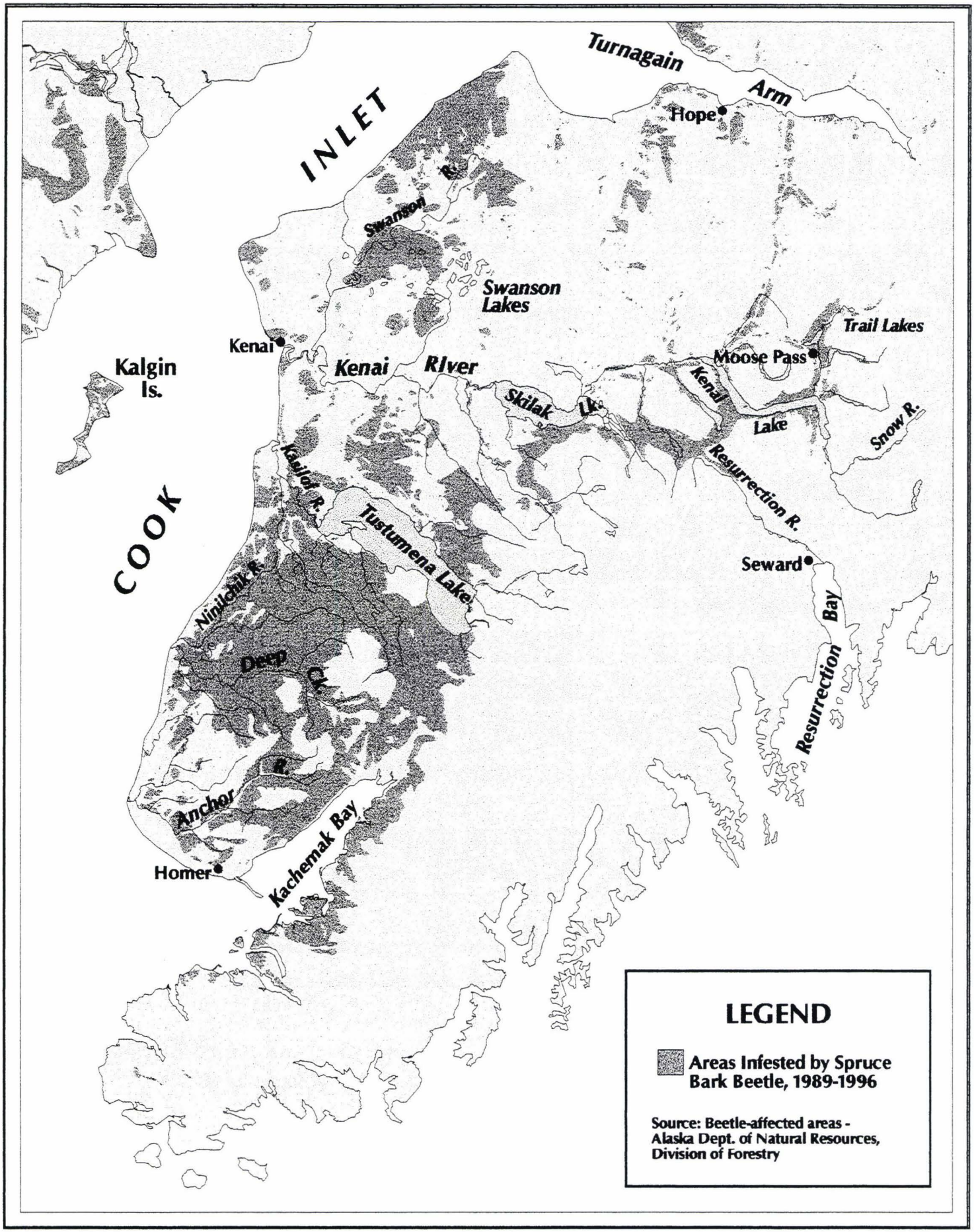




15 0 15 30 45 60 Miles

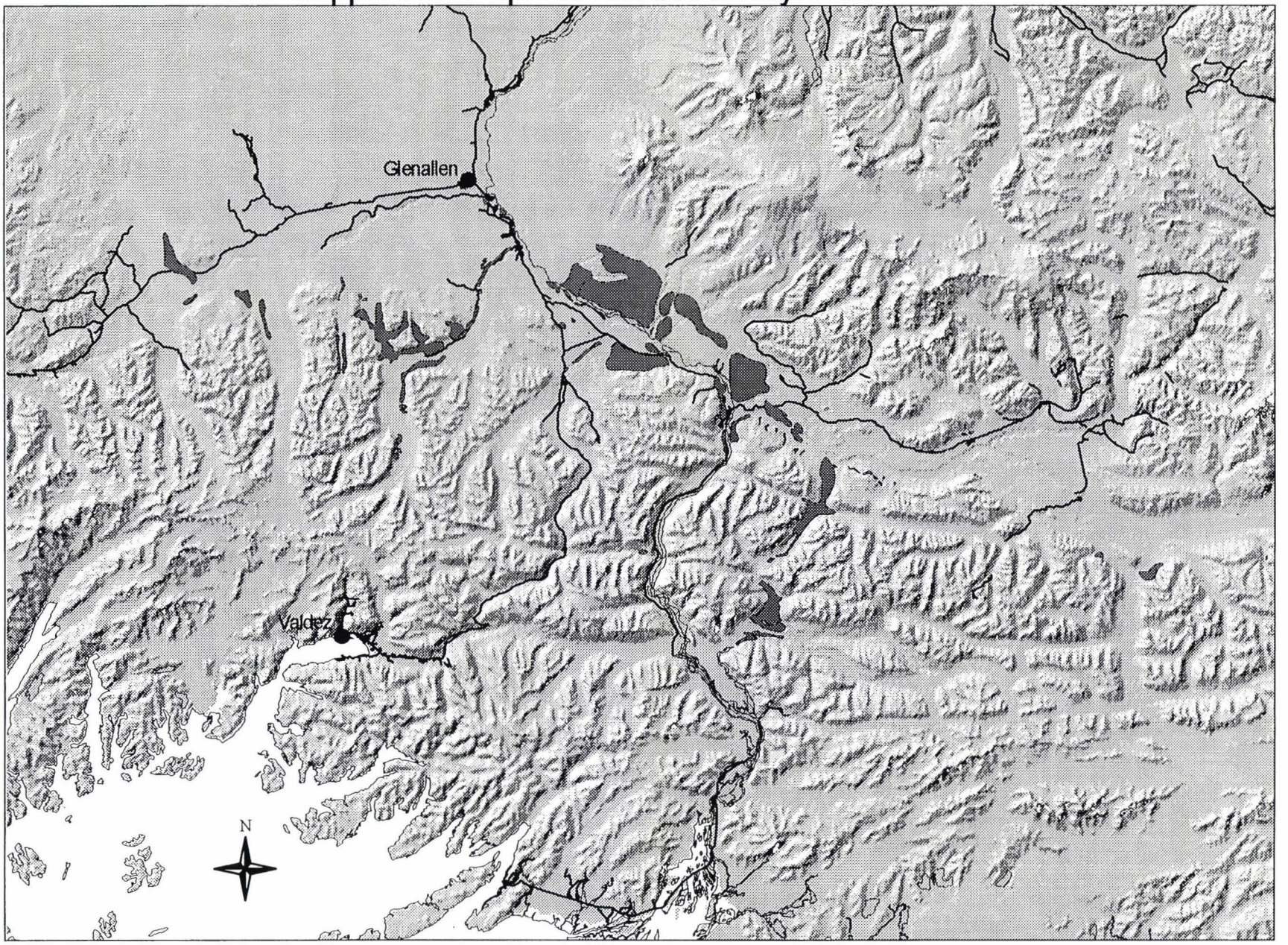


Primary Area of Bark Beetle Infestation Based On 1996 Aerial Surveys



Primary Area of Bark Beetle Infestation Based On Aerial Surveys 1989 - 1996

Copper River Spruce Beetle Activity:1996



10 0 10 20 Miles

10 0 10 20 30 40 Kilometers

Projection: Albers Equal Area Conic

Extent of Spruce Beetle Infestation

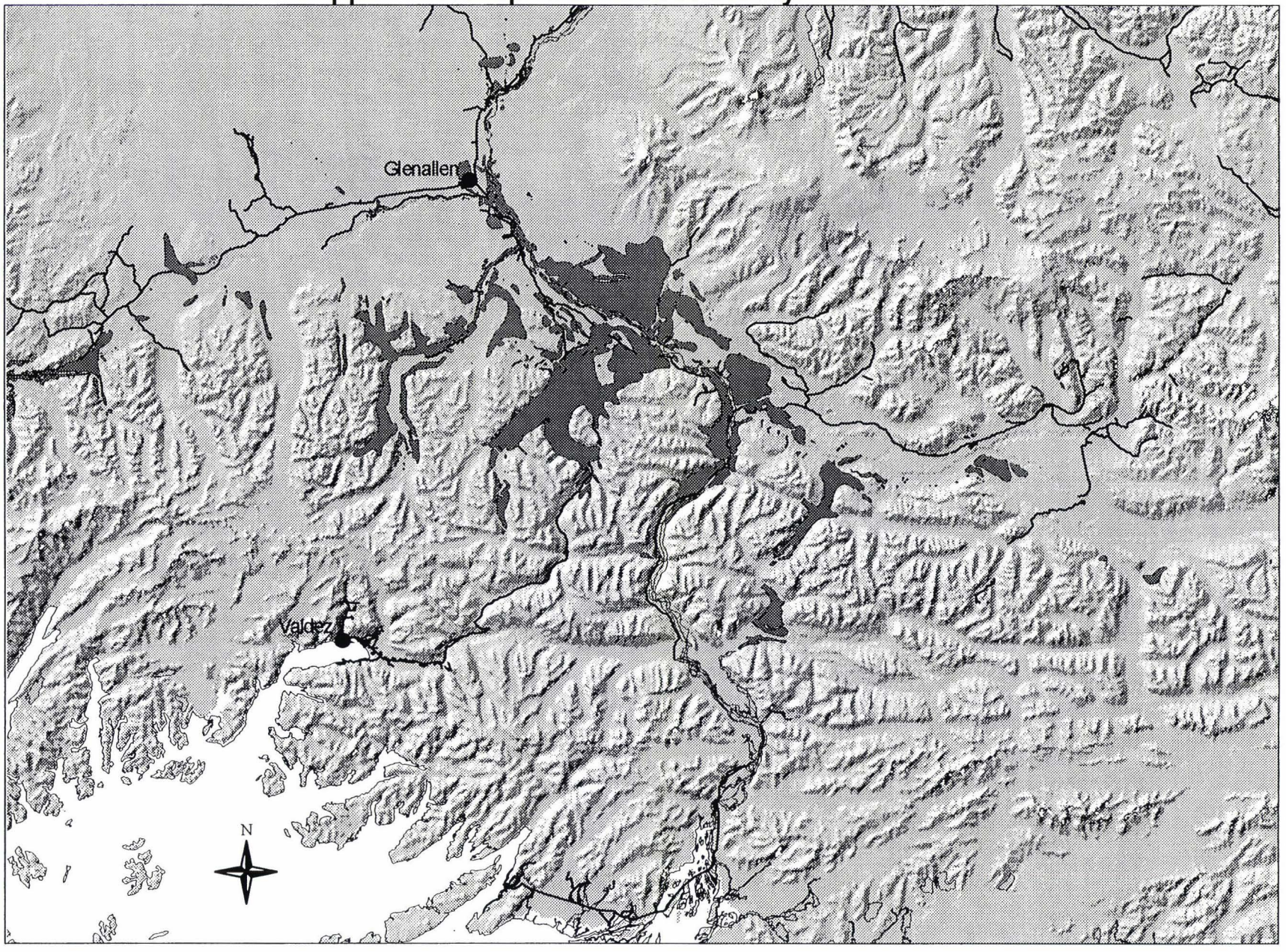
Roads

Map shows minimum extent of beetle-killed trees within the Copper River Basin; not all areas within the basin may have been surveyed.

Other data from Prince William Sound/Copper River Integrated Ecosystem GIS CD by Pacific GIS, Ecotrust, and Conservation International.

Map produced by: Resource Data, Inc. (RDI)

Copper River Spruce Beetle Activity: 1989 - 1996



10 0 10 20 Miles

10 0 10 20 30 40 Kilometers

Projection: Albers Equal Area Conic

Extent of Spruce Beetle Infestation

Roads

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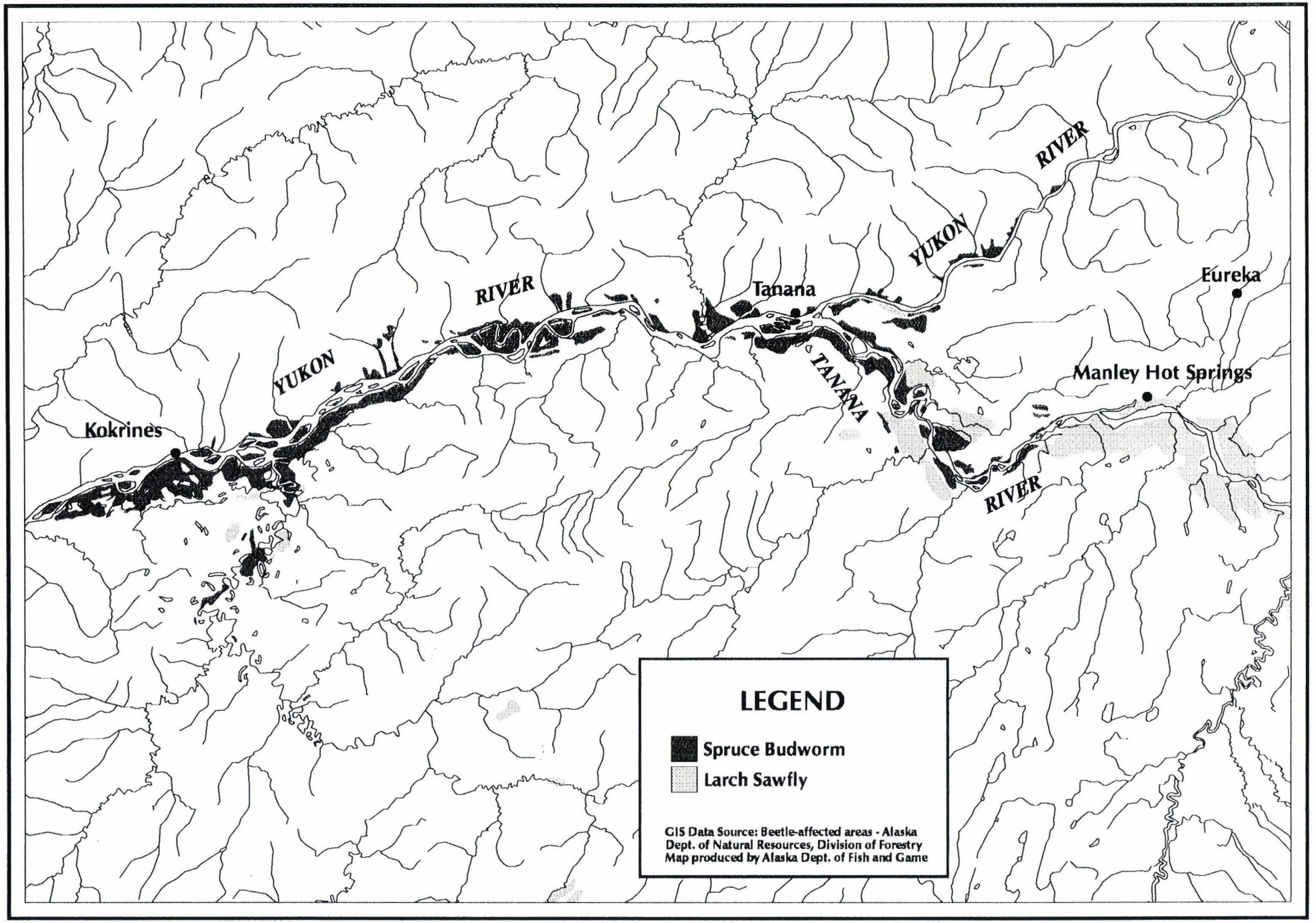
Other data from Prince William Sound/Copper River Integrated Ecosystem GIS CD by Pacific GIS, Ecotrust, and Conservation International.

Map produced by: Resource Data, Inc. (RDI)



Areas of Spruce Budworm and Larch Sawfly Infestation-Yukon/Tanana Rivers Junction Based On 1996 Aerial Surveys